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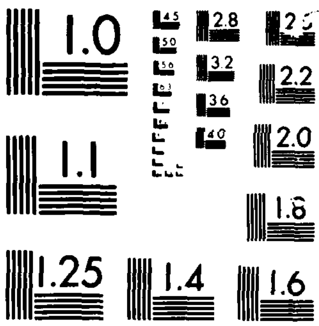

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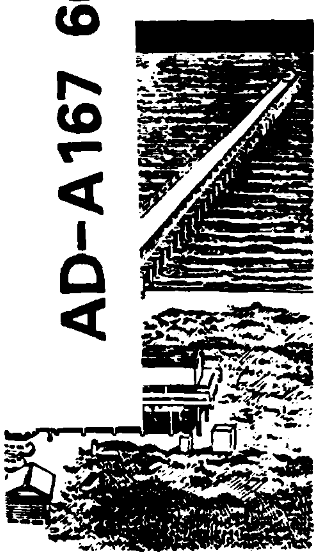

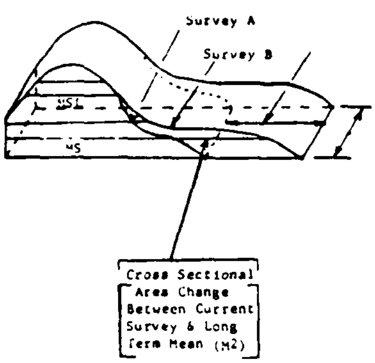

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BEACH CHANGES AT JONES BEACH LONG ISLAND, NY, 1962-74

by

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February 1986

Final Report

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report is one of a series of reports providing analysis and interpretation of beach profile data obtained between 1962 and 1974 by the US Army Coastal Engineering Research Center (CERC) as part of the Beach Evaluation Program (BEP). BEP was initiated after the Great East Coast Storm of March 1962 to observe variations on typical beaches in response to waves and tides of significant intensity and duration.

(Continued)

20. ABSTRACT (Continued).

Beach profile data obtained from surveys of 18 profile lines on Jones Beach are analyzed. Replicate measurements of vertical beach profiles were made between October 1962 and June 1974 by the US Army Engineer District, New York. Survey sheets and topographic maps marked with profile line locations were prepared. Elevations above mean sea level for each profile survey were determined. From these data, changes in beach elevation, sand volume, and shoreline position resulting from the wave regime, water level, and storm events that occurred during the period of the surveys are evaluated. In addition, previous work in the area is reviewed to examine long-term trends in waves, winds, and tides and to develop a framework in which to interpret beach changes.

Variability in the shape of the beach was evaluated with standard methods used at CERC as well as empirical eigenfunction techniques. Notable were changes in beach elevation, slope, volume, and mean sea level intercept resulting from particular storms. Evaluations were made for (a) long-term changes that occur over periods of a year or greater; (b) seasonal changes that occur over a typical 3-month period; and (c) short-term changes resulting from specific storms or wind stress events between surveys.

Over the long term, eastern Jones Beach has been gradually eroding because of lack of a sediment source to replace sand transported alongshore to the west. The previous source (Fire Island) was eliminated when jetties were built to stabilize Fire Island Inlet. To minimize this gradual starvation, Fire Island Inlet is periodically dredged and dredged material is disposed of on eastern Jones Beach, thereby reducing landward migration of Jones Beach. The western part of Jones Beach has accreted, as sand from the east is trapped at Jones Inlet jetty.

Winter storms consistently reduce beach levels. Rapid beach recovery is partly due to natural onshore transport and to spring beach-grooming activities, resulting in nearly complete beach recovery within 1 month following storms.

Tropical storms, coastal storms, and inland storms all erode the beaches in this vicinity, and Jones Beach is susceptible to wave damage from all of them. The rapid storm recovery discussed above seems to be typical of southern Long Island beaches. Beaches along other similarly exposed coastlines often have a longer recovery time because of persistence of higher energy frequency waves. Jones Beach is shown to be more typical of open ocean beaches. Wave climate at Jones Beach is low and tidal range is small (about 1 meter).

Jones Beach appears to be fairly stable in the long term, if the present program of replenishment from Fire Island Inlet continues along with seasonal manual grooming and if storm events occur no more frequently than they have over the past few decades. The beach can be expected to retreat significantly faster if nourishment is halted.

PREFACE

This report is one of a series describing the results of the US Army Coastal Engineering Research Center (CERC) Beach Evaluation Program. One aspect of the program, and the subject of this report, is to provide basic engineering information on changes in shoreline position, as obtained from long-term beach survey projects. The study of Jones Beach on Long Island was begun in 1962 and continued through 1974. The work was carried out under the CERC beach behavior and restoration program.

This report was prepared by Robert W. Morton (Principal Investigator), Science Applications, Inc. (SAI), Newport, Rhode Island; W. F. Bohlen, Marine Science Institute, University of Connecticut, Groton, Connecticut; and David G. Aubrey, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts. Eigenfunction and wave refraction analysis programs were written by D. Aubrey, while the remaining analysis software was provided by Joseph Karpen (SAI, Raleigh).

The authors acknowledge and appreciate the review and comments provided by the personnel of CERC. On 1 July 1983 CERC was transferred to the US Army Engineer Waterways Experiment Station. A. E. DeWall was the Contract Monitor for the Evaluation Program, under the general supervision of R. M. Sorenson, Chief, Coastal Processes and Structures Branch, CERC. Chief of CERC during the publication of this report was Dr. J. R. Houston.

Director of WES was COL Allen F. Grum, USA. Technical Director was Dr. Robert W. Whalin.

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CONTENTS

* Appendixes A-I are on file at the Coastal Engineering Research Center, WESCW, US Army Engineer Waterways Experiment Station, and are available for loan.

BEACH CHANGES AT JONES BEACH
LONG ISLAND, NY, 1962-74

I. INTRODUCTION

1. Background

This report is one of a series of reports providing analysis and interpretation of beach profile data obtained between 1962 and 1974 by the US Army Coastal Engineering Research Center (CERC) as part of the Beach Evaluation Program (BEP--formerly known as the Pilot Program for Improving Coastal Storm Warnings, or the Storm Warning Program). The BEP was initiated after the Great East Coast Storm of March 1962 in order to observe variations on typical beaches in response to waves and tides of significant intensity and duration. Twelve beaches in the region hardest hit by that storm (Massachusetts to North Carolina) are under study in this program. Other applications of the BEP include generating a predictive model of beach erosion and providing basic engineering information for the planning and design of protective structures or remedial strategies for stabilizing and maintaining beaches (Everts, 1973).

This report presents an analysis of beach profile data obtained from surveys of 18 profile lines on Jones Beach. Replicate measurements of vertical beach profiles were made between October 1962 and June 1974 by the New York District of the US Army Corps of Engineers. Survey sheets and topographic maps marked with profile line locations are included in Appendix A.*

* Appendixes A-I are on file at the Coastal Engineer Research Center, WESCW, US Army Engineer Waterways Experiment Station, and are available for loan.

Measurements of elevation above mean sea level for each profile survey are presented in Appendix B.

An analysis of these data is provided which evaluates changes in beach elevation, sand volume, and shoreline position resulting from the wave regime, water level, and storm events that occurred during the period of the surveys. In addition, previous work in the area is reviewed to examine long-term trends in waves, winds, and tides and to develop a framework in which to interpret beach changes.

Variability in the shape of the beach was evaluated with standard methods utilized at CERC (Appendixes C, D, and E) as well as empirical eigenfunction techniques (Appendixes G and H). Of particular note were changes in beach elevation, slope, volume, and mean sea level (MSL) intercept resulting from particular storm events. Changes were evaluated over three time scales:

(a) Long-term changes that occur over periods of a year or greater;

(b) Seasonal changes occurring over a typical three-month period; and

(c) Short-term changes resulting from specific storms or wind stress events between surveys.

2. Previous Work

The south shore of Long Island consists of eroding or reworked glacial deposits from the Wisconsinan glaciation. Since the glacial sediments were deposited (about 14,000 years before present), they have been extensively reworked by subaerial, fluvial, and marine processes. A large number of researchers have extensively studied the marine reworking processes occurring at Jones Beach and more generally throughout the area. The New York

District of the US Army Corps of Engineers has performed repeated studies of this area (1951, 1961, 1963, 1971). Other studies of interest include Howard (1939), Wilby et al. (1939), Kumar (1973), Rampino (1979), and McCormick and Toscano (1980).

In addition to site specific studies covering Jones Beach, New York, other studies of barrier beach migration which are of interest include Sanders (1963), Schwartz (1967 and 1971), Swift (1968), Hoyt (1967), Dillon (1970), Otvos (1970 and 1979), Kraft (1971 and 1973), Dolan (1973), Armon (1975), Godfrey and Godfrey (1975), Sanders and Kumar (1975), and Swift (1975). Leatherman (1980) presents an annotated bibliography of these and other studies pertinent to barrier changes at Fire Island, Long Island, New York.

II. THE STUDY AREA

1. Geology and Geomorphology

The Jones Beach study area is located approximately 40 kilometers southeast of New York City near the western end of the south shore of Long Island, New York (Fig. 1). The beach, a segment of the barrier system fronting much of the south shore, extends for a distance of approximately 24 kilometers from Jones Inlet on the west to Fire Island Inlet on the east, and serves as the offshore limit for a complex bay and island system. Both inlets are stabilized by jetties constructed by the federal government. The Fire Island jetty was completed in 1941 and the Jones Inlet jetty in 1959. This entire area of shorefront is publicly held and divided into a series of recreational beaches. Jones Beach State Park occupies the western-most 9.5 kilometers of beachfront. Adjoining to the east is Tobay Beach owned by the Town of Oyster Bay, followed by Gilgo Beach, Cedar Island Beach, and Oak Beach, all owned by the Town of Babylon. The availability of public access and the proximity of these beaches to high population density urban centers make this an extremely popular recreational area. Estimates indicate that it is visited by more than 10 million people annually.

The beachfront between Jones and Fire Island Inlets is a broad, low-lying structure composed primarily of medium to fine sands. The sediment distributions along the bordering dune line and across the beachface appear to be essentially homogeneous, with no indication of coarser grained pockets of gravel or till.

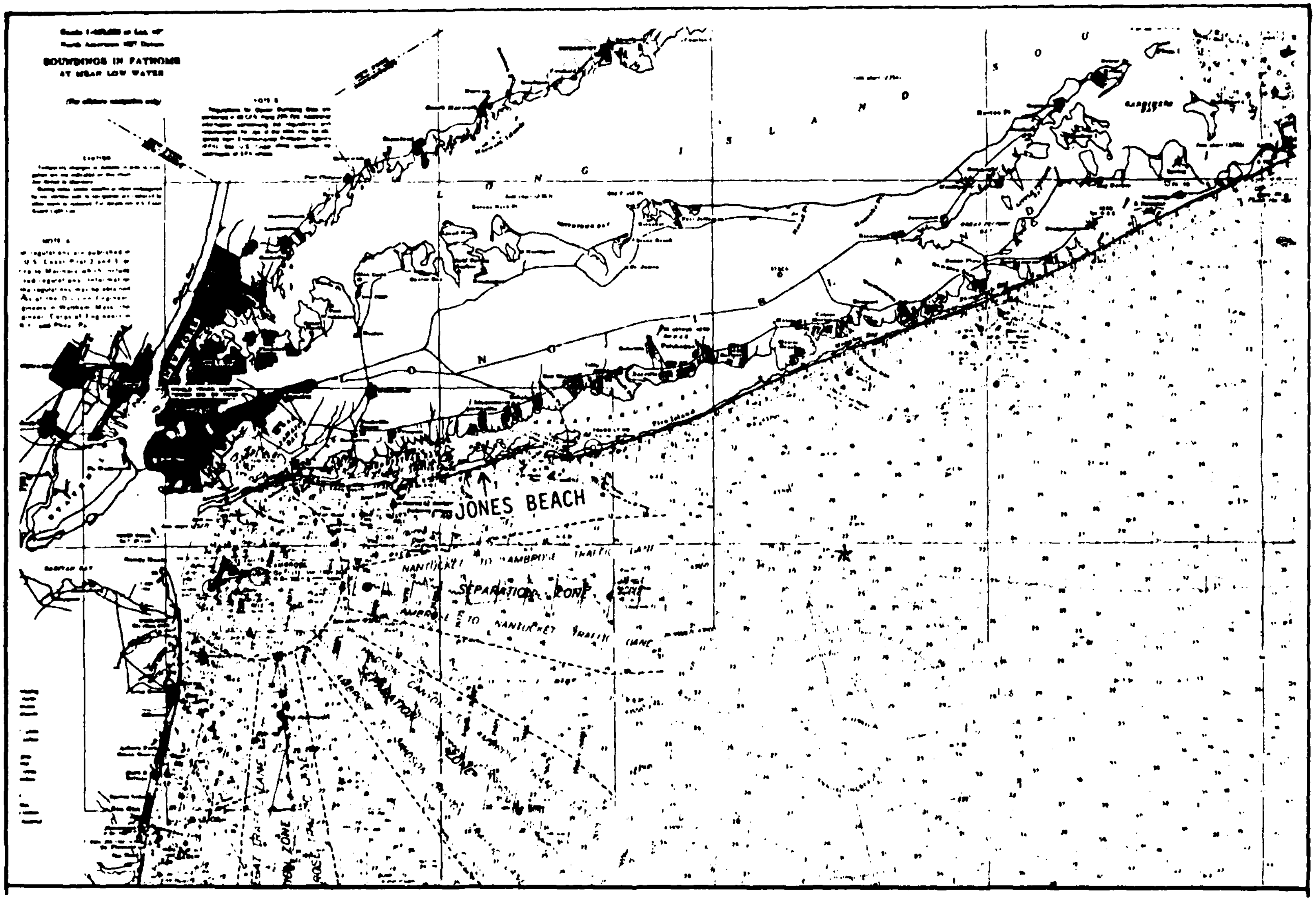

Figure 1. Jones Beach location

The sediments forming the beach are glacial in origin and supplied primarily by the combination of ice advance and meltwater runoff from the Ronkonkoma moraine and its attendant outwash plain (Panuzio, 1969). Studies indicate that the beach has migrated shoreward since the termination of the last glacial advance and may have been initially located approximately 7 kilometers offshore of its present position (Sanders and Kumar, 1975). The form and rate of migration have been the subjects of continuing debate (Leatherman, 1980).

Proceeding easterly from Jones Inlet, present beach width above mean high water progressively decreases from approximately 225 meters adjacent to the Jones jetty, to slightly less than 35 meters near the eastern end of Gilgo Beach. From this point east to the vicinity of Fire Island Inlet the trend reverses and beach width increases, reaching a maximum of approximately 600 meters at the Oak Beach dike near the entrance to Fire Island Inlet. Beach width on the dike is quite variable, but generally remains less than 10 meters. Along its entire length the beachfront displays smooth, regular, planform contours with little evidence of spatial periodicity.

In elevation the beachfront typically displays slopes ranging from 1:5 within the intertidal zone, to near horizontal across the berm. Berm elevations average approximately 2 to 3 meters above the mean sea level surface. Within the extensive dune field forming the backshore along most of the beach, elevations increase abruptly on slopes of 1:20 with maximum crest elevations approaching 6 meters above mean sea level. This pattern is interrupted only in the area of Jones Beach State Park

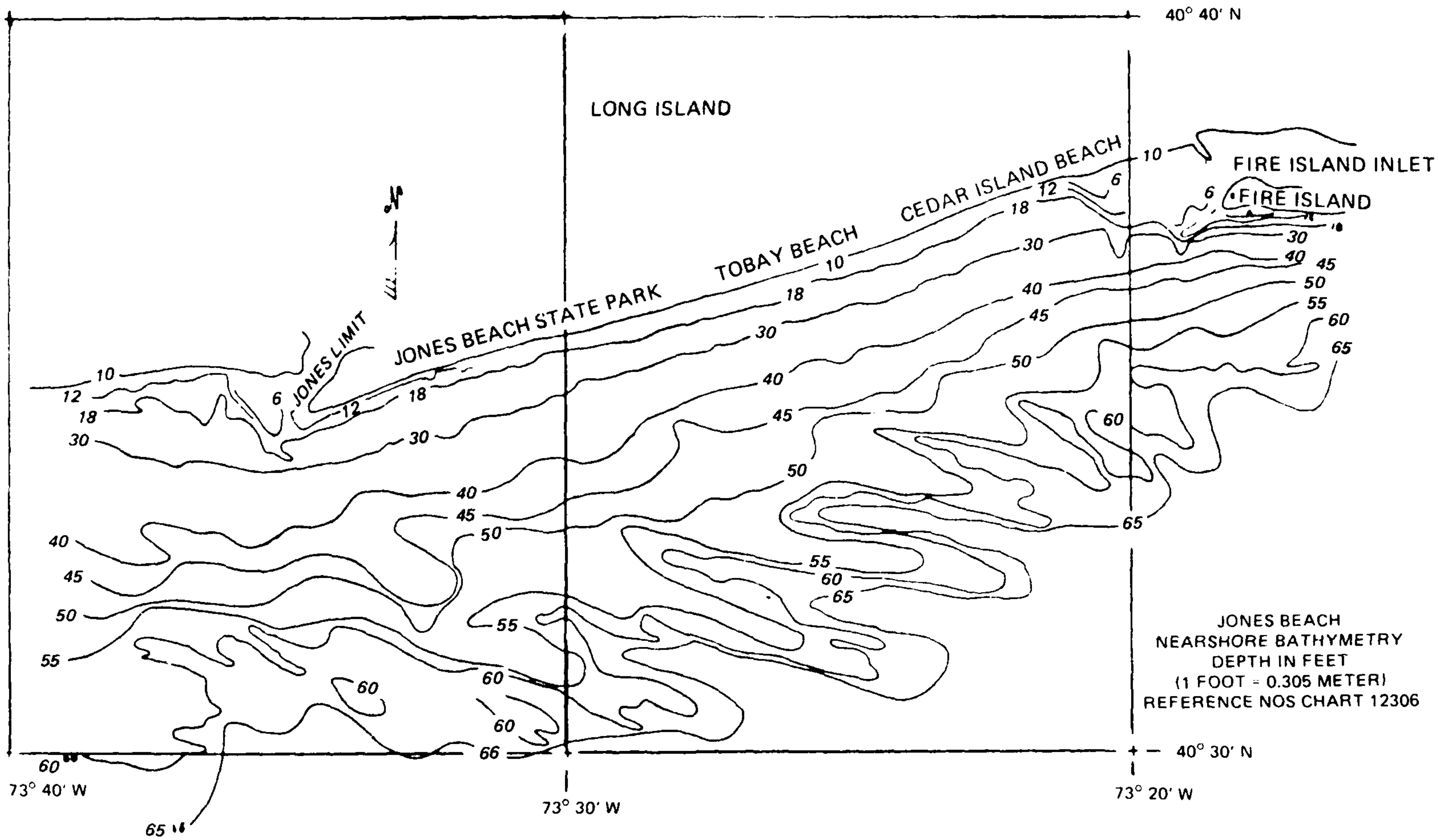

Figure 2. Nearshore bathymetry

where extensive portions of the dune line have been replaced by buildings and a boardwalk.

2. Offshore Bathymetry

The Jones Beach study area forms a portion of the northern limit of the New York Bight, an area of the continental shelf offshore of New York Harbor which is bordered to the north by Long Island, to the west by the New Jersey shore, and extends seaward to the edge of the continental shelf, a distance of approximately 100 kilometers. Surface sediment of this area of the shelf consists primarily of fine to medium sands and occasional pockets of coarser grained glacial materials (Williams, 1976; McKinney and Friedman, 1970). The major fraction of these sediments is essentially similar to that found along the beach, suggesting that at least in part the shelf offshore represents a source for materials forming the beach. Within the nearshore zone out to the 10-meter isobath, depth contours are essentially shore parallel (Fig. 2); depths increase progressively with distance offshore at slopes of approximately 1:250. Beyond this region, slopes decrease to 1:400 to 1:1000, and mean depth contours display progressive rotations due to the northwest-southeast trending Hudson Canyon (Fig. 3). This feature dominates the larger scale bathymetry within the New York Bight.

On a smaller scale, the shelf bottom in the area fronting the beach consists of bedforms displaying a wide range of spatial and temporal variability. Within the immediate nearshore, observations document a series of oblique, shore-attached bars. The characteristics of these features do not appear to have been studied in any detail. Further offshore, in the vicinity of the

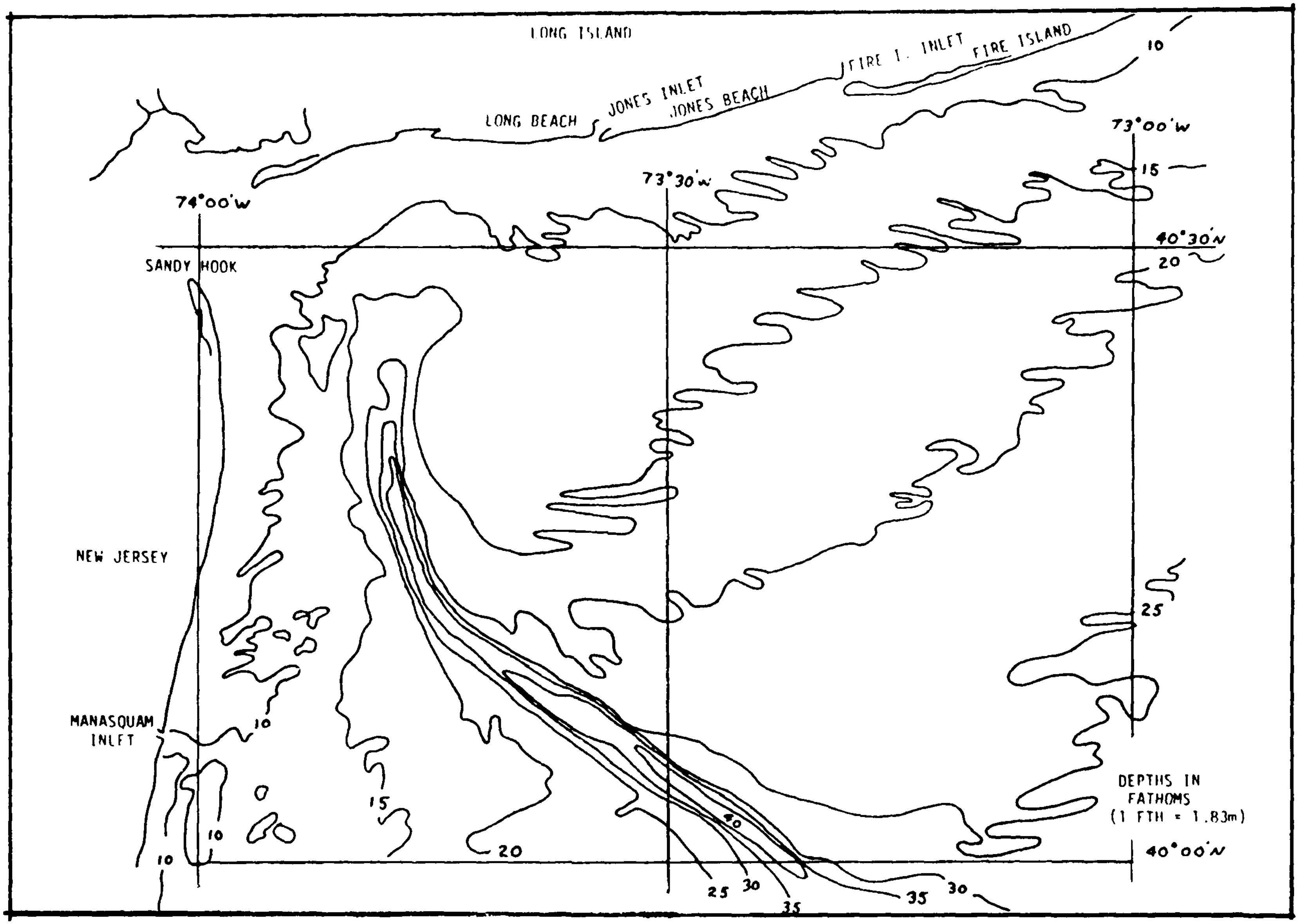

Figure 3. Offshore bathymetry

20-meter isobath, a well developed ridge and swale system persists, which continues to the edge of the continental shelf. This system of linear shoals has been studied in detail and used to evaluate portions of the geological history of the area, as well as to provide insights into the processes governing modern sediment transport along this portion of the continental shelf (Duane et al., 1972).

3. Littoral Processes

Sediment movement along and across the beaches between Jones and Fire Island Inlets is the result of a variety of factors including winds, surface waves, tidal currents, sea level advance, and the activities of man. These factors act collectively and individually to affect the rates and routes of sediment transport and the ultimate shape of the beach.

a. Tides. The tidal system within the New York Bight is dominated by the semidiurnal lunar tide. Tides in the vicinity of the Fire Island Inlet display a mean range of 1.26 meters, and a spring range of 1.53 meters. Adjacent to Jones Inlet the range decreases slightly, with a reported mean range of 1.1 meters and a spring range of 1.32 meters. Associated tidal currents display maxima of approximately 2.4 knots (120 centimeters per second) on both the ebb and flood within Fire Island Inlet, and 3.1 knots (155 centimeters per second) on the flood and 2.6 knots (130 centimeters per second) on the ebb in Jones Inlet. Further offshore, a recent set of detailed observations obtained at a site located 2 kilometers west of Fire Island Inlet in approximately 10 meters of water indicate mean near bottom velocities with maximum speeds of approximately 0.6.

knot (30 centimeters per second) (Lavelle et al., 1976). Velocities in this area displayed significant temporal variability, and near bottom transport was evidently sensitive to surface wind conditions and the associated wave field. Previous observations within an 8- by 10-kilometer rectangle located midway between Jones and Fire Island Inlets and approximately 9 kilometers offshore yielded similar results and indicated a dominant easterly drift with aperiodic westerly perturbations induced by storm systems which were characterized by easterly winds (Lavelle et al., 1976). These observations suggested that the mean circulation within the northeastern Bight , at least during the fall and winter months, is dominated by a clockwise gyre. Circulation within the area appears to be dominated by the local wind systems, with significant sediment transport confined to storm periods.

Average tidal conditions can be significantly perturbed during aperiodic storm events. The maximum observed tidal heights adjacent to the study area are 2.9 meters and 2.8 meters above mean sea level at Jones Inlet and Oak Beach, respectively (observed during the storm of 25 November 1980). U.S. Army Corps of Engineers estimates indicate that such heights have an average frequency of occurrence of approximately once in 50 years.

b. Winds. Winds along the south shore of Long Island are seasonal, with southwesterlies favored during the summer and northwesterlies in the winter (Fig. 4). Average velocities in the area are generally less than 5 to 7 meters per second, with summertime conditions dominated by an onshore seabreeze.

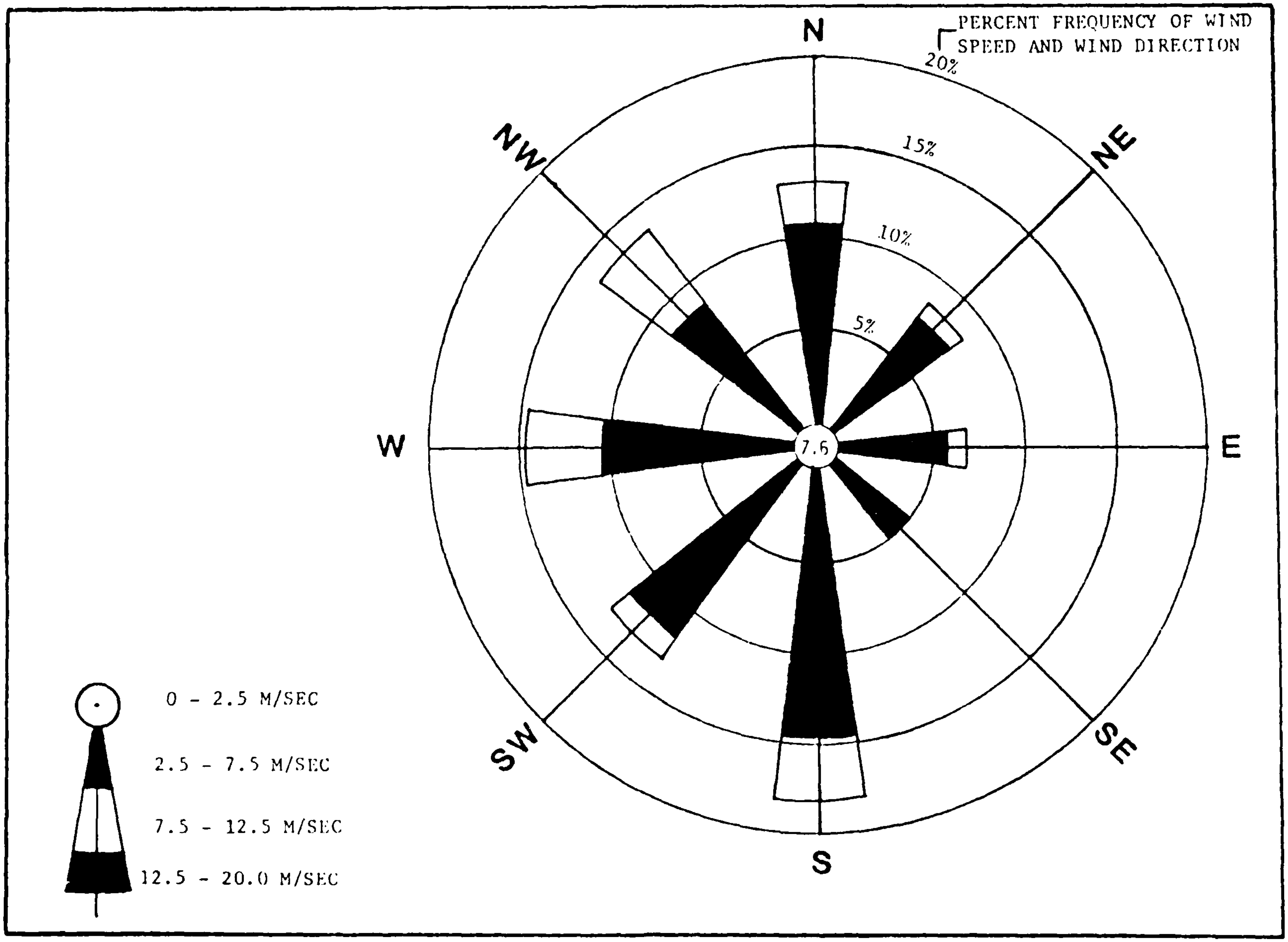

Figure 4. Wind rose, Fort Totten, New York, for the period January 1962 to December 1974

The inter-relationship between storm activity and beach response is difficult to define in an historical sense. Generally, only storm history or beach response is well-known, with the other quantity (history or response) roughly estimated from one of several sources. Information on significant (destructive) storm events is particularly difficult to obtain, lacking direct measurements. Historical storm accounts are generally incomplete and often inaccurate. Wave hindcasts are only now becoming available, and need to be verified for most coastal locales before being used indiscriminately.

As an alternative to an historical compilation, a listing of all cyclones (both tropical and extra-tropical) reaching the geographical limits of 70°W to 75°W, 40°N to 42.5°N, was used as an indicator of storm activity. This information (Fig. 5) shows high storm activity in the early 1970's, with relatively less in surrounding periods. The hypothesis is that the number of storms is an indicator of storm severity. While there is some merit to using the hypothesis, it is noted that extremely destructive storms hit the Long Island Coast in the years 1962 and 1963, two years in which total cyclone activity was relatively low. As the cyclone information is now presented, there is no weighting applied to reflect storm intensity (hence erosion potential). Lacking other storm or wave compilations, however, Figure 5 has been taken as a rough indicator of storm intensity for the period of the study.

A monthly average of cyclone intensity over the period 1885-1982 (Fig. 6) shows a definite seasonal trend. The months from November through April show a mean value of 2.2 cyclones per

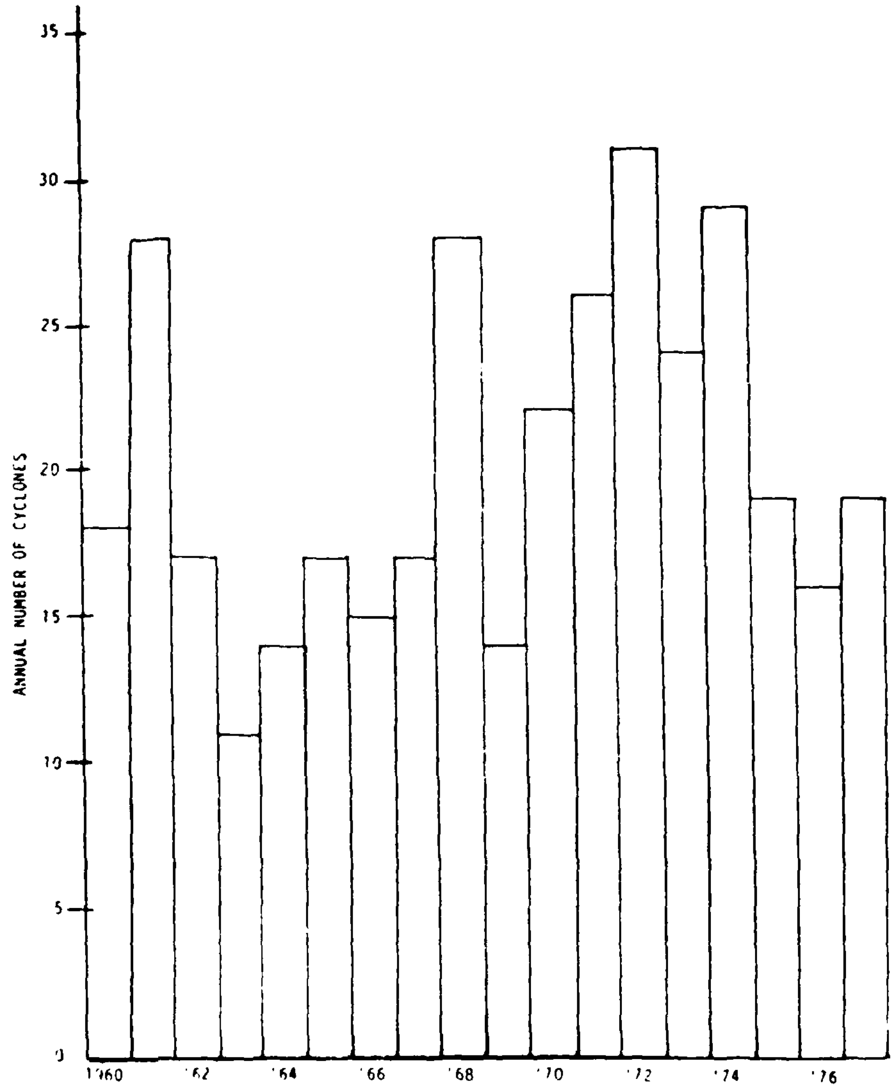

Figure 5. Annual cyclone occurrence (1960-1977)
Long Island, NY

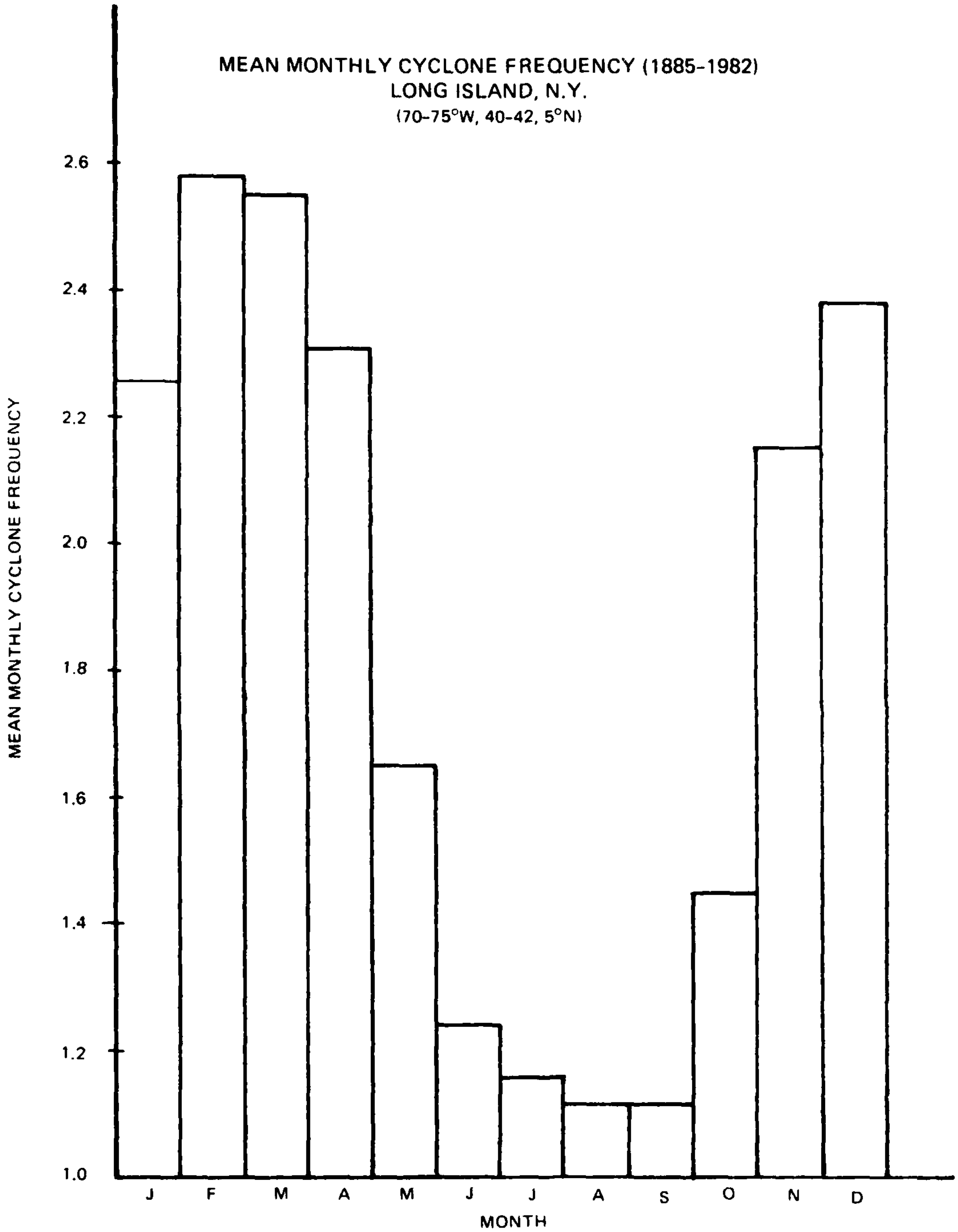

Figure 6. Mean monthly cyclone frequency

month or greater. The months of June through September show monthly cyclone frequencies of less than 1.3 cyclones per month, while the months of May and October have intermediate values. If the erosion on this beach were insensitive to direction of cyclone winds, it could be expected to reflect this seasonal storm activity. This is probably not the case, however, since peak winds from these storm events generally come from the easterly or westerly sectors. Winds having high velocity southerly components, and accordingly high erosion potential, usually represent transient conditions occurring during the passage of the storm center or associated frontal system. Reduced erosion can therefore be expected.

c. Surface Waves. The location and orientation of the Jones Beach study area is susceptible to maximum incident wave energy from the east through the south-southwest. Hindcast techniques applied to a site near the entrance of New York Harbor indicate that for the period 1948 to 1950, 72% of all deep-water waves approach from the northeast to southeast quadrant. Calculated maximum heights for these waves range between 7.6 and 9.2 meters. The maximum period equals approximately 14 seconds (Panuzio, 1969). Such waves are expected to occur less than 0.2% of the observation period. Estimates of the frequency of occurrence of less energetic, but more common, waves indicate that for approximately 60% of the time wave height remains below 1.2 meters. Waves greater than 1.2 meters will occur 28% of the time; waves greater than 2.5 meters 9.5% of the time; waves greater than 4.3 meters 2% of the time; and waves greater than 5.5 meters approximately 1% of the time.

Adjacent to the study area intermittent wave observations were obtained during 1950 to 1954 using a bottom-mounted pressure gage sited at several locations between Jones and Fire Island Inlets. The resultant data indicated a mean wave height of 0.36 meter and a maximum height of 4.1 meters. Waves 0.6 meter or greater prevailed for approximately 20% of the time, while waves greater than 3 meters occurred 1% of the time (Panuzio, 1969).

In addition to the hindcast and wave gage data there have been several visual wave observation programs conducted in the vicinity of the study area. A summary of surf observations obtained during the period 1954 to 1957 at a station adjacent to Jones Inlet is given Table 1. These observations are consistent with previous data, indicating that surf height is generally less than 1.25 meters, with waves typically coming from the southeast through southwest quadrants.

The closest CERC wave gage reported by Thompson (1977) for this region is in water 5.2 meters deep, along the Steel Pier (39°21'N, 74°25'W) at Atlantic City, New Jersey, and has operated almost continuously from 1957 to 1969. Although the Atlantic City gage is somewhat distant from Long Island (160 kilometers), the seasonal trends in climate should be similar at the two locations. Prior to 1968, analysis was run on 7-minute pen-and-ink records taken six times daily. After November 1968, results were obtained from 1024-second digital records taken four times daily.

Figure 7 shows the annual significant period distribution for the span December 1968-October 1969, and for the span 1965-1967. The predominant modal period is approximately 9 seconds.

Table 1

Summary of Surf Height and Wave Direction Observations. Short Beach Lifeboat Station, October 1954 to December 1957

Month	Surf Height in Feet (%)[a]				Wave Direction (%)[b]			
	0-1.9	2-3.9	4-5.9	6-9.9	E	SE	S	SW
January	37	51	12	0	6	48	4	42
February	29	66	5	0	1	32	10	57
March	39	48	12	1	2	49	6	43
April	38	53	8	1	6	44	6	44
May	43	53	4	0	3	34	26	37
June	54	45	1	0	0	42	18	40
July	44	54	2	0	0	30	22	48
August	55	40	5	0	0	44	16	40
September	37	59	4	0	0	56	11	33
October	43	45	10	2	1	46	28	25
November	35	53	11	1	5	37	26	32
December	42	48	9	1	2	33	25	40
Total Period	41	51	7	1	2	41	17	40

(a) All observed surf heights were less than 10 feet.

(b) No waves were observed approaching from any of the other directions which are not listed.

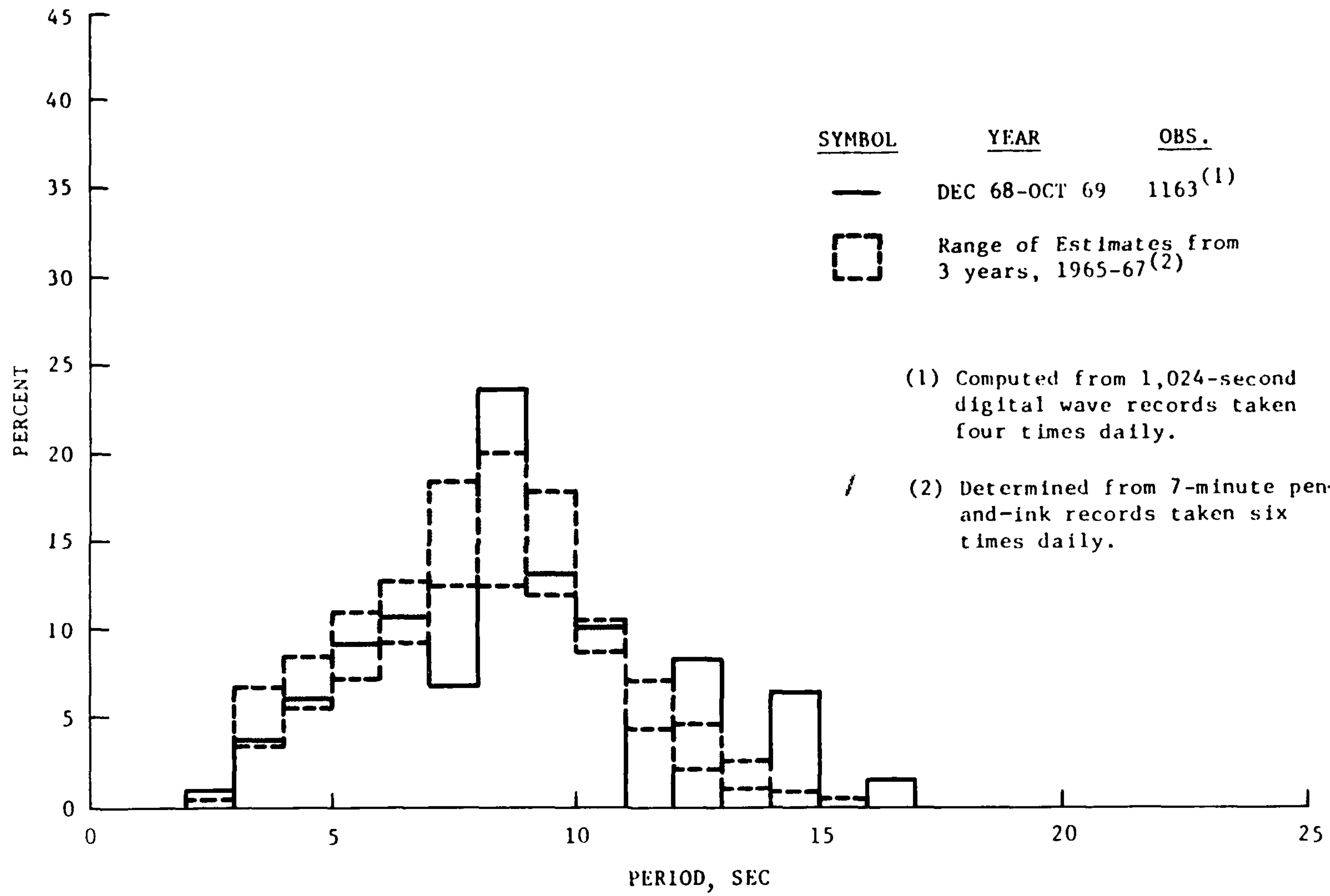

Figure 7. Annual significant wave period distributions from Atlantic City, New Jersey

Mean monthly wave period height and data are presented in Figure 8. A peak period occurs in December and January of near 9 seconds, decreasing smoothly to a minimum of 7.2 seconds in April. September has a secondary peak with a mean period of 9.3 seconds. Wave height throughout the year is low except in September. Mean significant wave height hovers between 0.7 and 0.8 meter, except for September when the monthly average is near 1.3 meters.

d. Sea Level Advance. Local records of sea level indicate a consistent, long-term rise in the area adjacent to Jones Beach (Hicks, 1968 and 1972; Lennon, 1977). Although of secondary importance when compared to other factors, variations in mean sea level are an important consideration when assessing long-term trends in beach profile development. Observations at Sandy Hook, New Jersey, and within New York Harbor indicate over the period 1940 to 1970 a persistent advance of 4.6 and 2.9 millimeters per year, respectively. Over the total period of record for each site (1893-1976 for New York and 1933-1976 for Sandy Hook) an average advance of 3.8 millimeters per year for New York and 4.9 millimeters per year for Sandy Hook has been reported (Permanent Service for Mean Sea Level, 1977). Both sets of observations display significant temporal variability; the period 1960 to 1965 showed a slight decrease in relative sea level stand at Sandy Hook. New York observations revealed a slight decrease in 1960-1961, an increase in 1961-1962, and then a relatively large decrease from 1963 to 1965. After 1965, a trend for sea level rise dominated both sets of observations, and by 1970 sea level was approximately 1 centimeter above the level observed in

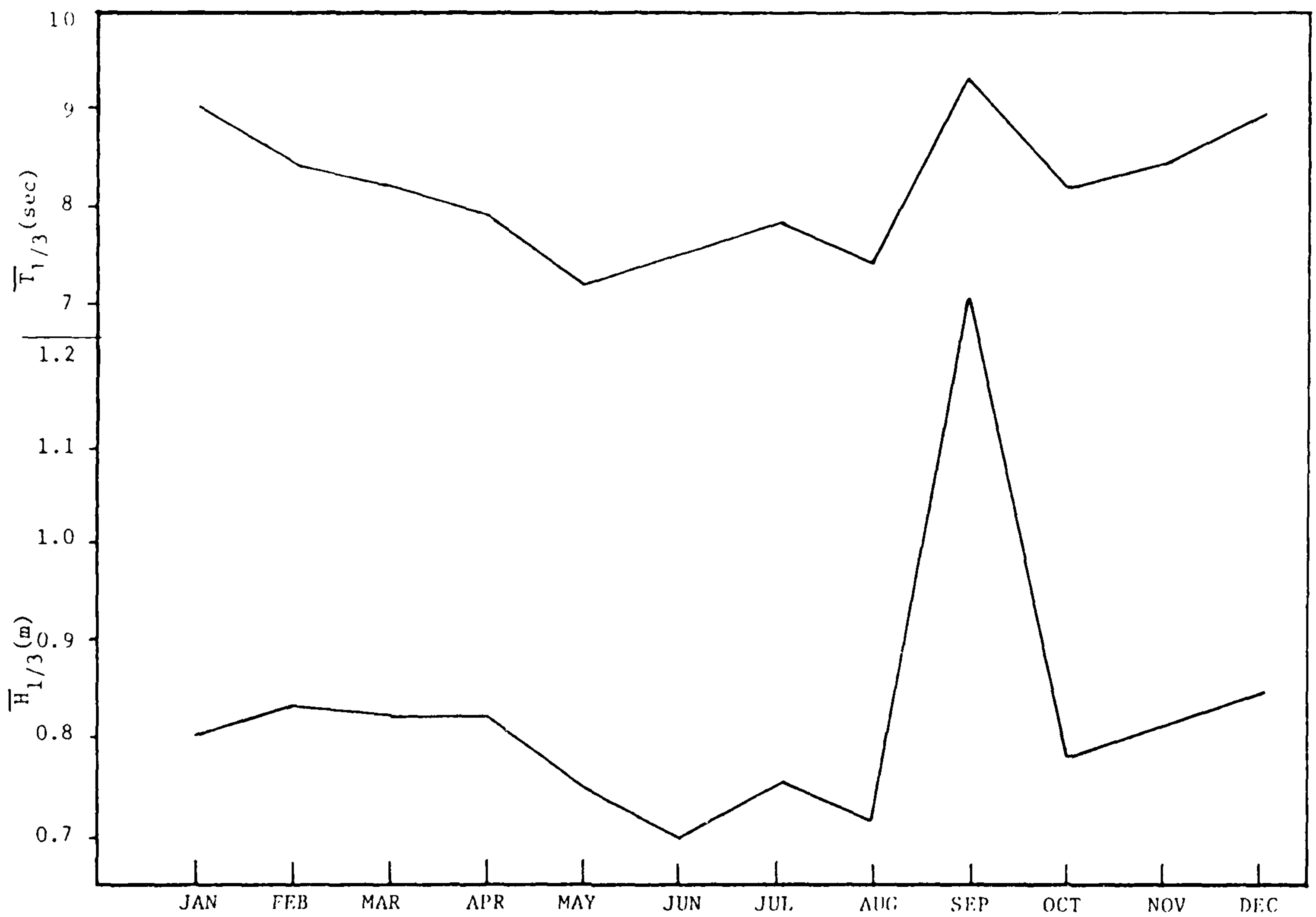

Figure 8. Annual significant wave height and period

1960 at New York and 3 centimeters above the 1960 observation at Sandy Hook. The cause for these short-period fluctuations is still not known.

The observed range of sea level advance at Sandy Hook over a period of ten years and in the absence of profile re-adjustment could result in a horizontal transgression along Jones Beach of approximately 0.3 meter on the beachface immediately shoreward of the intertidal zone.

e. Man's Activities. Along the beachfront between Jones Inlet and Fire Island Inlet, the activities of man have been confined primarily to the development of recreational beach areas and the control of erosion and stabilization of the shoreline. To provide recreational access, a roadway has been constructed along the length of the beach behind the primary dunes, on a line located approximately midway between the southern shoreline and the inshore bay. Development along this road has been carefully limited to parking lots and a few administrative buildings and bath-houses. Only within the confines of Jones Beach State Park has extensive building down to and along the dune line been permitted. In this area much of the beach front is bordered by boardwalk or park-related buildings. The only private housing along the beach is located on the eastern end in the vicinity of Oak Beach. Located within Fire Island Inlet, this area is essentially sheltered from significant direct wave attack.

To control erosion and to stabilize the shorefront in the area of the recreational beach, the Corps of Engineers in 1939 initiated a phased program consisting of jetty construction and

sand bypassing. The first jetty at Fire Island Inlet was completed in 1941. Prior to its construction the inlet was migrating progressively westward at a rate of approximately 64 meters per year (1825-1940)(Sanders and Kumar, 1975) as part of a longshore transport system with annual volume rates of 300,000 to 600,000 cubic meters (Panuzio, 1969). The Jones Inlet jetty was constructed next and completed in 1959. Concurrently, a closure dike was constructed along the west end of Oak Beach (Fig. 9) to relieve erosion in the area produced by tidal currents through Fire Island Inlet. Following this construction, Fire Island Inlet was dredged and approximately 2,000,000 cubic meters of sand were placed along the beachfront extending approximately 4.6 kilometers west of the Inlet. Inlet dredging and beachfront placement of spoils were repeated in 1964. Again, approximately 2,000,000 cubic meters of sand were placed on the beach.

In addition to Army Corps of Engineers operations along the beach, the towns of Babylon and Oyster Bay and the Jones Beach State Park annually place snow fences to reduce the loss of wind-blown sand during the winter months and mechanically groom the beachfront during the spring and early summer.

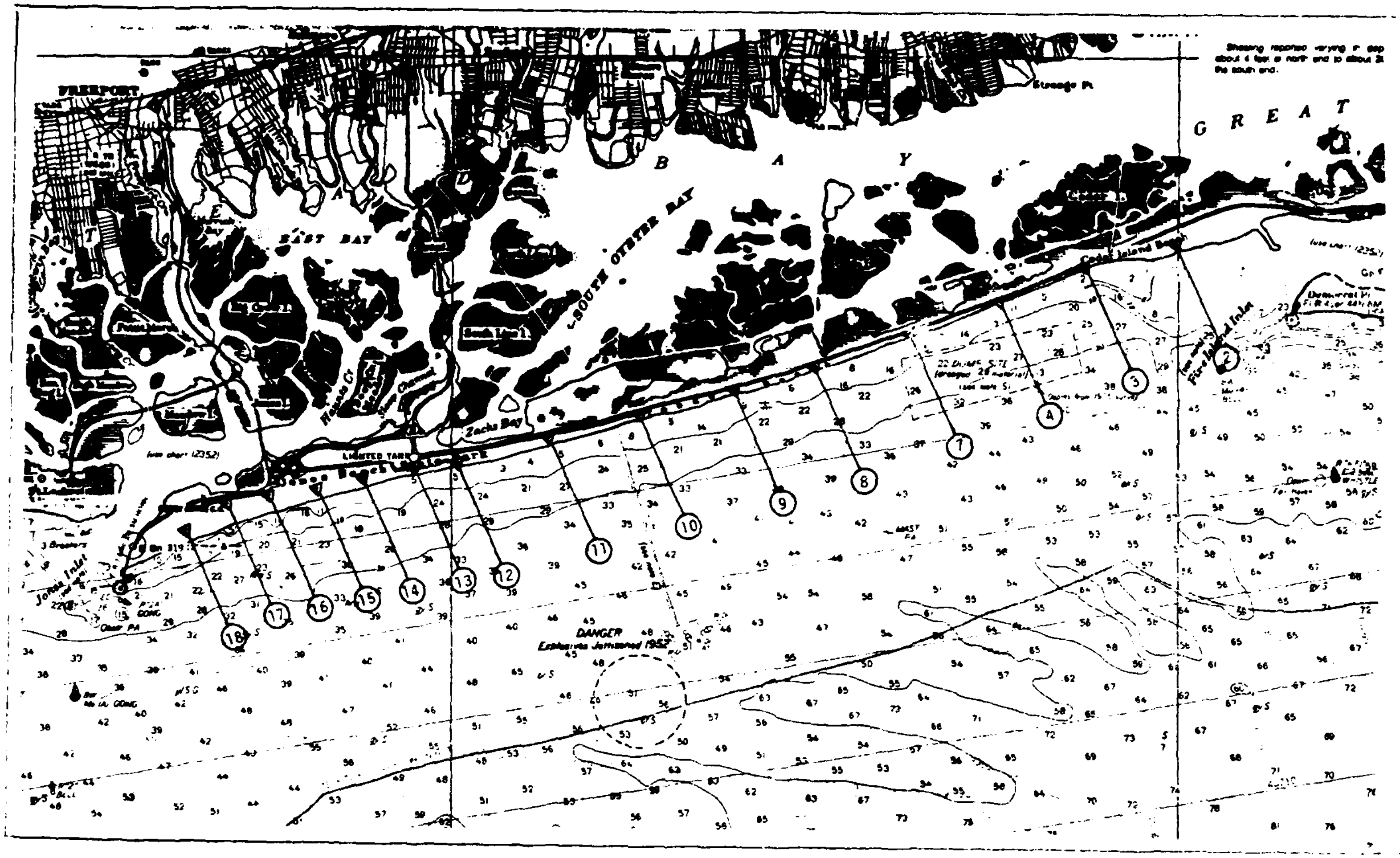

Figure 9. Profile line locations

III. METHODS

1. Profile Lines and Monumentation

a. Profile Line Location. Fifteen profile lines, numbered 2-4 and 7-18, were regularly monitored along Jones and adjacent beaches over the 1962 to 1974 BEP study period. Figure 9 shows the relatively consistent spacing of these profile lines. Profile line 1 was monitored only from October 1962 to March 1966 for a total of 30 surveys. Profile lines 5 and 6 were surveyed just three times in 1966. No data regarding the location of these three profile lines (1, 5, 6) are available.

A complete report prepared by CERC in 1980 documenting the locations of profile lines 2-4 and 7-18 is included in Appendix A. Horizontal and vertical control information along with topographic charts and photographs of 11 of the 15 lines are included.

b. Survey Frequency. Surveys were conducted on Jones Beach profile lines 2-4 and 7-18 from October 1962 to June 1974. Between 111 and 114 surveys were conducted on each of these lines. Figure 10 provides annual survey frequency information grouped by seasons. Consistent records were kept thoughout the period with at least one survey conducted per season except for fall of 1965, summer and fall of 1968, and summer of 1974. A monthly survey compilation (Fig. 11) shows significantly more surveys were conducted during the winter months of December, January, and February when storm-related beach activity was expected to be greatest.

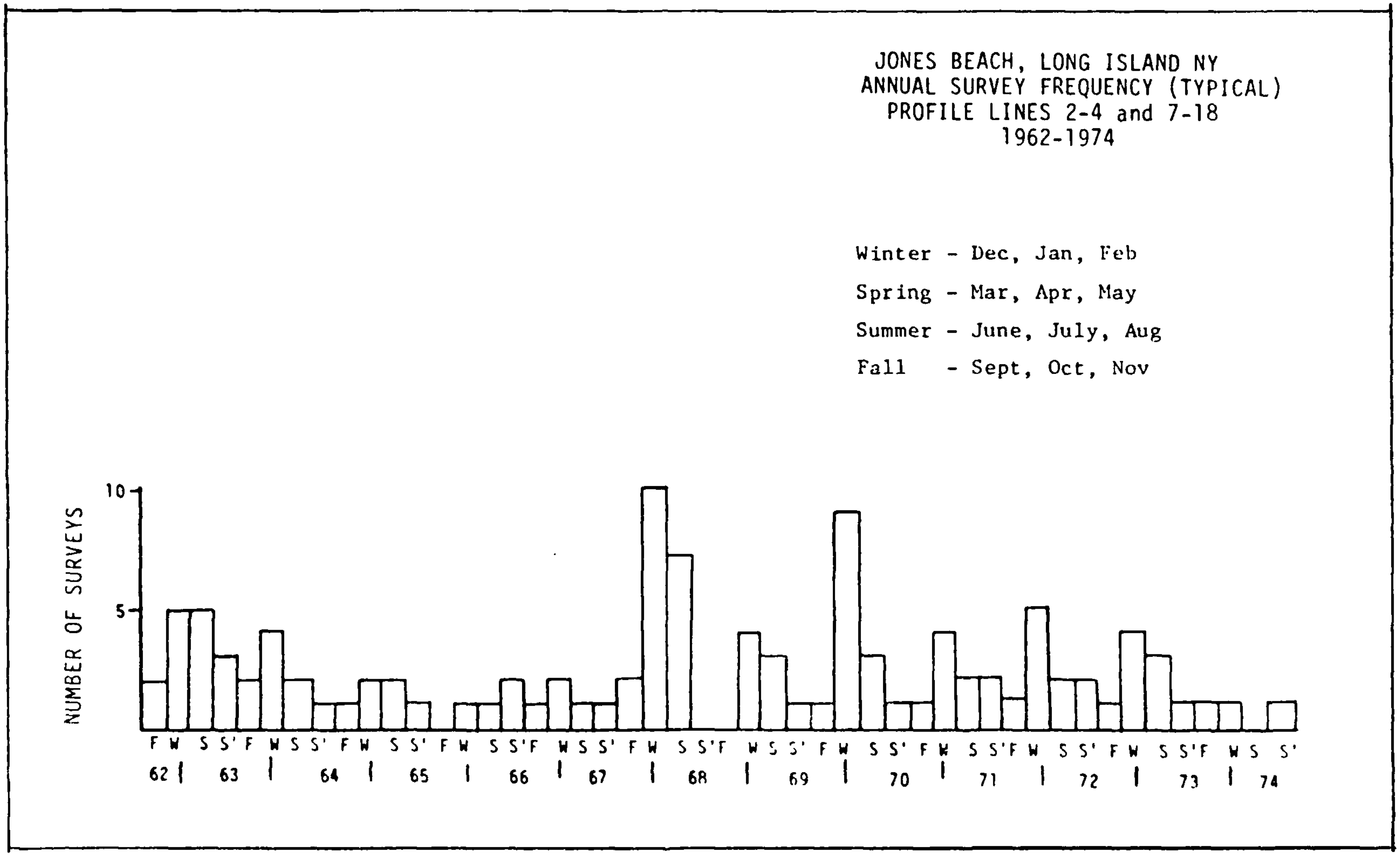

Figure 10. Annual survey frequency

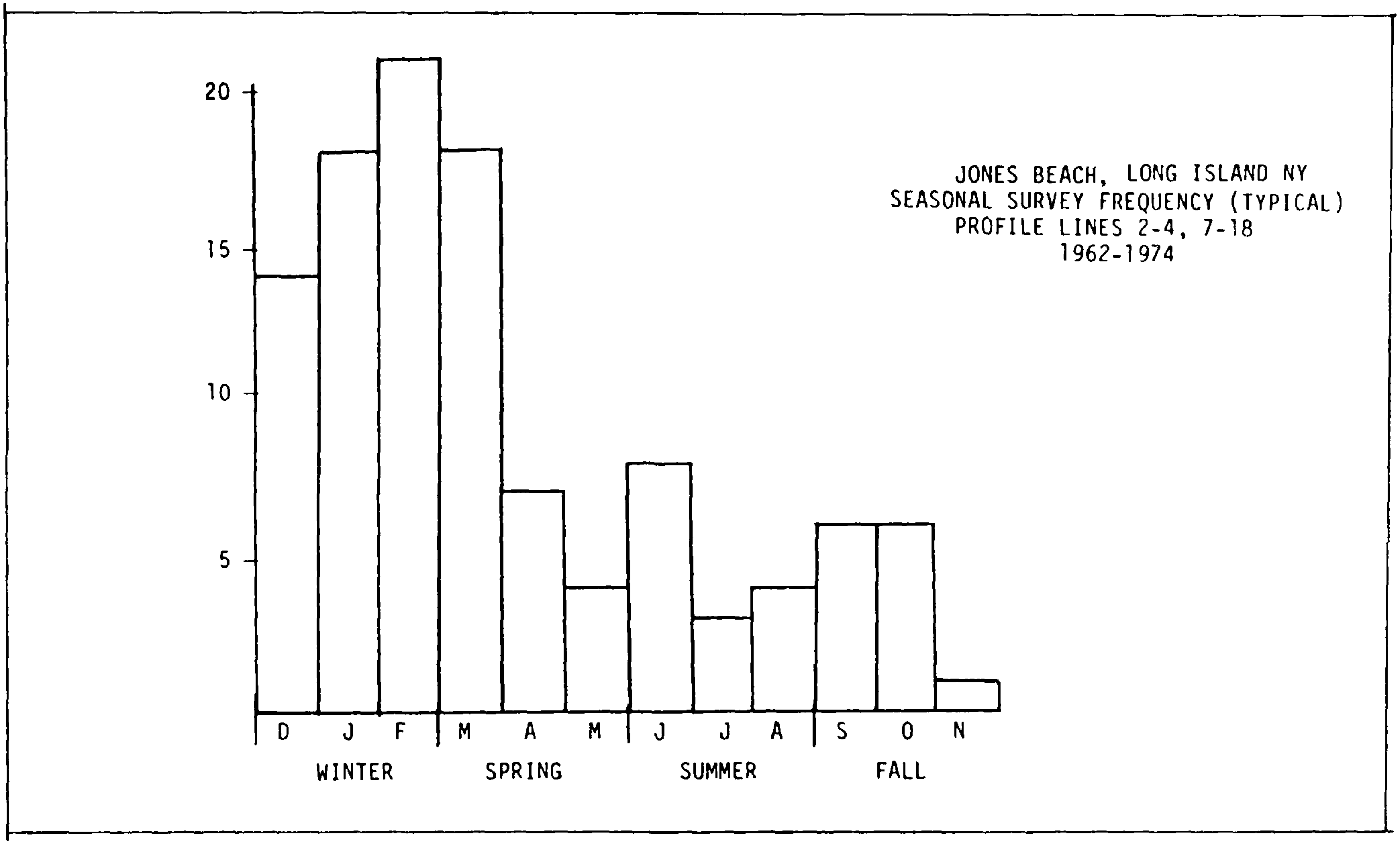

Figure 11. Seasonal survey frequency

2. Analytical Procedures.

a. Profile Line Analysis. Profile line surveys were analyzed by CERC, and computer plots were generated for changes in above MSL volume relative to the long-term mean (App. C), changes in MSL shoreline intercept from the original survey (App. D), and profile envelopes (App. E). The origin of the coordinate system, to which all surveys are referred, is the monument location in the horizontal plane and MSL in the vertical.

The cross-sectional area under each profile was calculated as defined by three lines: (1) a vertical line projected from the landwardmost distance common to all surveys on a given profile line, (2) a horizontal line at the MSL elevation, and (3) the surveyed profile. The calculation was accomplished by summing the area of 30.5-centimeter horizontal slices through the area bounded by the profile from the highest elevation to MSL. The area change was then computed by subtracting the current measured profile area from the long-term mean cross-sectional area (Figure 12). Note that the change in area (and volume) were referred to the long--term mean and not the original or previous profile.

The plots in Appendix E are profile envelopes; i.e., the plots show two lines drawn through the upper and lower extremes of the surveyed sand elevations on each of the profile lines. The envelope of extremes contains points from many different surveys, rather than tracing a particular eroded or accreted profile found during one survey.

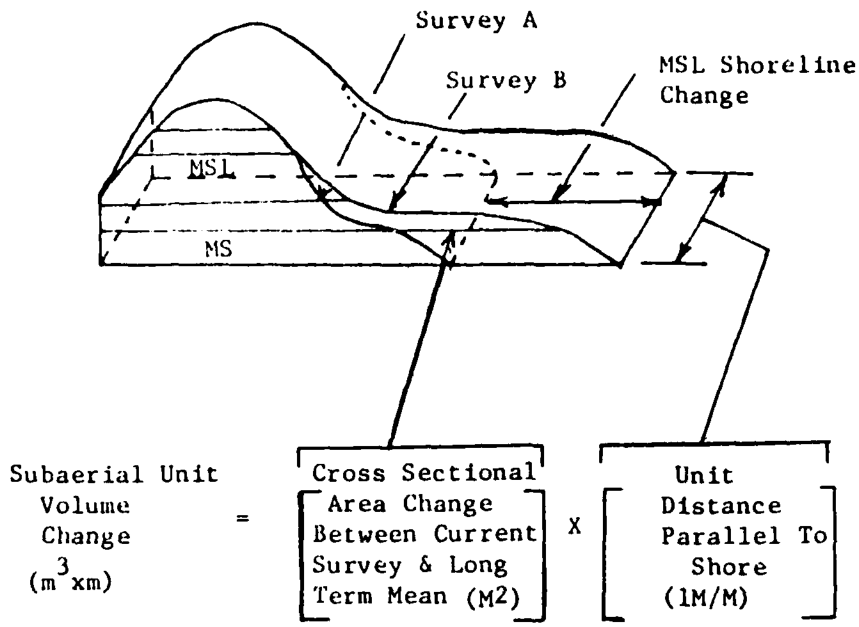

Figure 12. Definition of MSL shoreline and above MSL unit volume change

b. Empirical Eigenfunction Analysis. The temporal and spatial variability of each beach profile was also examined using empirical eigenfunction analysis. The results of this analysis are presented in Appendixes G and H. Although widely used in other scientific disciplines (Lorenz, 1959), this analysis has only recently been applied to separating sources of variability in coastal processes.

When applied to analysis of profile lines resurveyed over a period of time, the method quantifies the topographic variability in both the onshore-offshore and longshore directions through time. The technique has been applied to studies on beaches, islands, and other coastal features on both the Atlantic and Pacific coasts (Winant, Inman, and Nordstrom, 1975; Vincent, et al., 1976; Resio, et al., 1977; Aubrey, 1979; Miller, Aubrey, and Karpen, 1980; Miller, 1983). This technique provides a useful supplement to the "traditional" analytical procedures described above.

Eigenfunctions of the beach profiles were calculated in two ways. The first set (the mean eigenfunctions) was calculated on the entire profile, before removing the mean shape of the beach. The second approach was to subtract the arithmetic mean profile before calculating eigenfunctions (the de-meaned eigenfunctions). The two sets of eigenfunctions have different properties; but, in general, the n^{th} de-meaned eigenfunction is analogous to the (n+1) mean eigenfunction. Both calculations are useful for describing changes in beach configuration.

IV. RESULTS

1. Wave Data

a. Direct Local Observations. Long-term measurements of surface gravity waves at Long Island's south shore are limited to visual wave observations made as part of the BEP program. In-situ gage data are either short in duration, unreported, or non-existent. Hindcast estimates of wave conditions in this area have been reported by Panuzio (1969).

The BEP observations were made from 1968 through 1974 at Jones Beach. Coverage is sparse from May through October, but good from November through April (Figs. 13 and 14). This inadequate seasonal coverage makes it difficult to estimate longshore sand transport rates on a yearly basis. Over the duration of the BEP study, the mean wave period was 6.5 seconds (yearly standard deviation of 0.59 second), mean wave height was 0.80 meter (yearly standard deviation of 0.10 meter), and mean direction in sector, 2.89 (yearly standard deviation of 0.16), or from just east of south.

On a seasonal basis, monthly averaged values vary (Fig. 15) between 5.0 and 7.6 seconds. Large deviations from this mean of 6.5 seconds occur only in months with poor coverage (June, August, and October). Mean monthly wave height also shows little variation, ranging from 0.7 to 1.0 meter, with the largest values reported during poorly observed summer months. Wave patterns have an easterly component (from the east) over most of the year, except June when inadequate sampling was available.

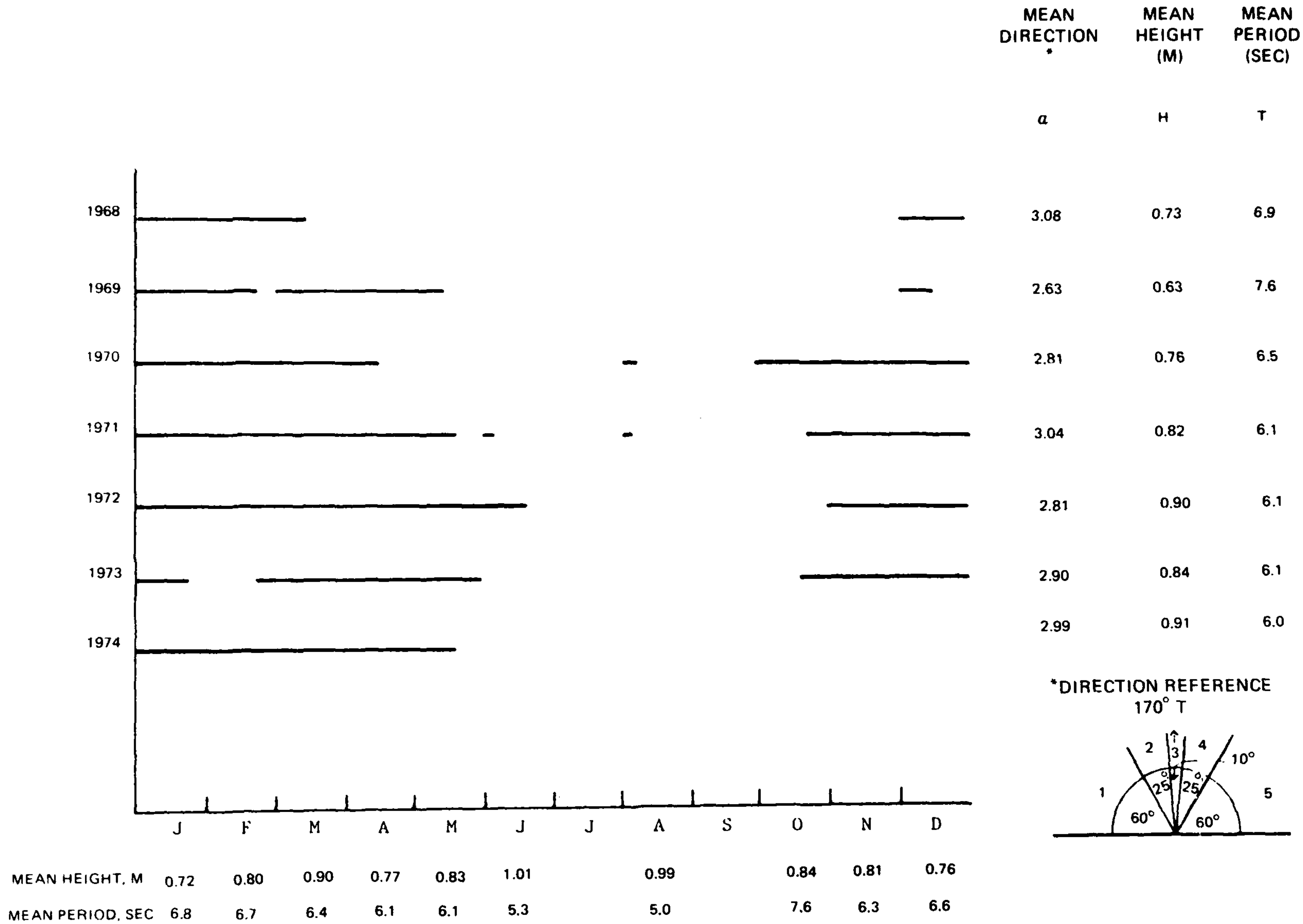

Figure 13. Yearly summary of BEP visual wave observations, Jones Beach, New York, 1968-1974

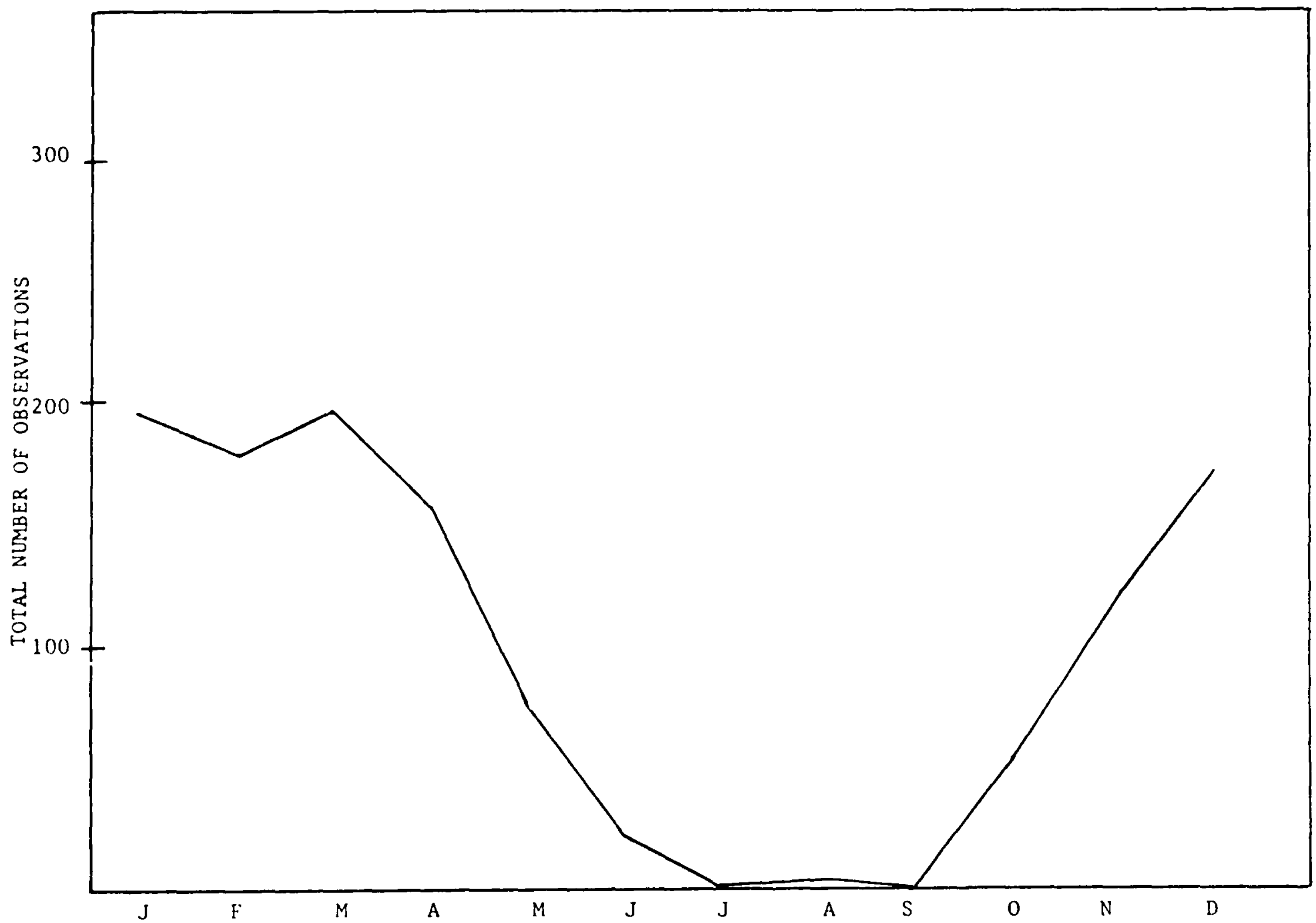

Figure 14. Monthly BEP wave observations, Jones Beach, New York, 1968-1974

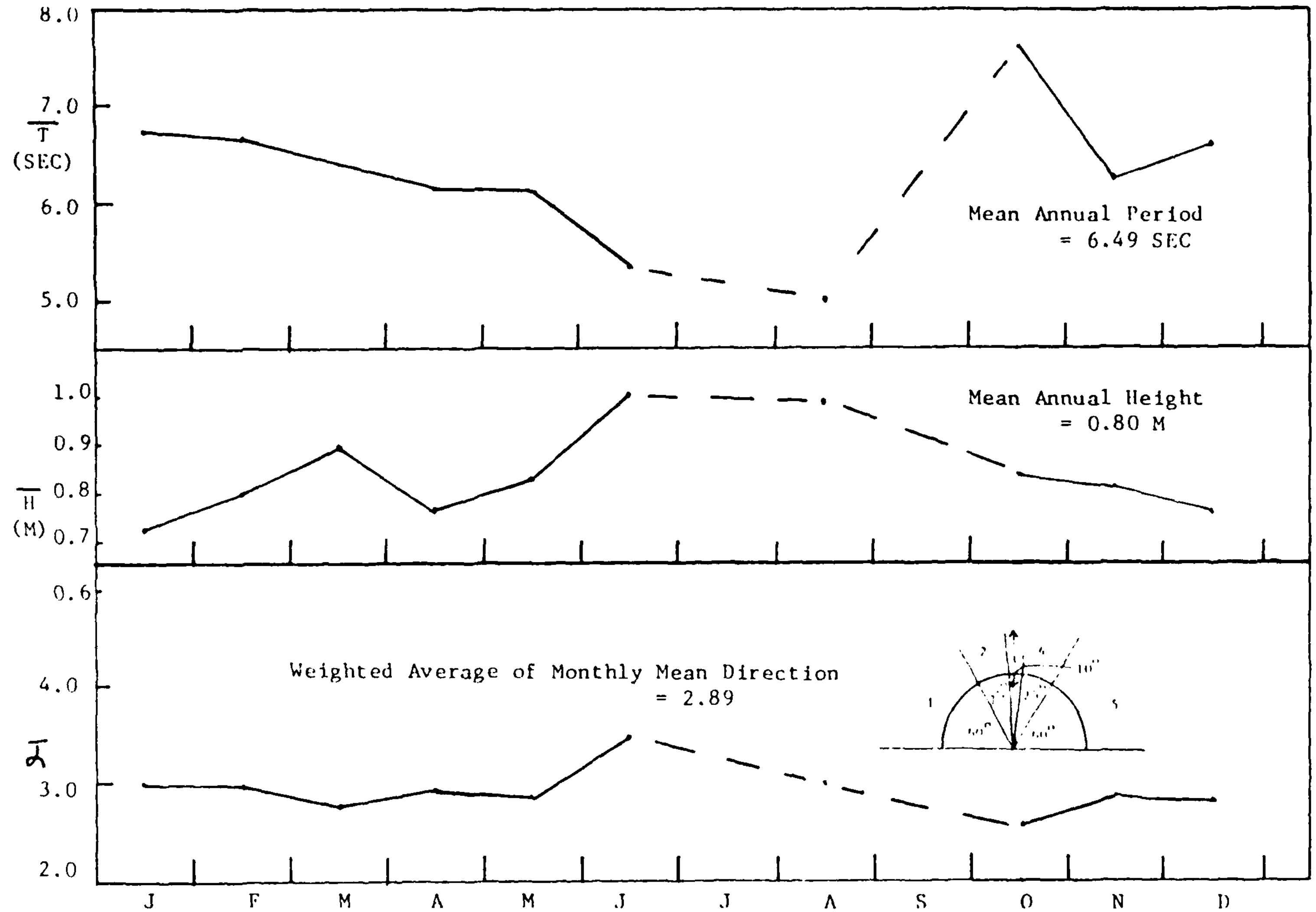

Figure 15. Monthly mean BEP wave characteristics, Jones Beach, New York, 1968-1974

Because of limited seasonal wave coverage, no attempts were made to estimate net longshore transport rates using the joint probability distributions of period, height, and direction. In any case, the wide direction bands reported in the visual observations preclude any rigorous calculations of sand transport rates.

b. Linear Wave Refraction. A wave propagation refraction modeling technique (Dobson, 1967) was used to develop a qualitative analysis of the surface wave field off Jones Beach. The method employs the wave height and period statistics collated by observation and hindcasts and assumes a uniform offshore directional distribution of the field. Based on the results of the BEP shore wave observations and the CERC Atlantic City wave gage, linear wave refraction was calculated for waves with periods of 6, 9, and 12 seconds, propagating in 15° directional segments covering the 180° offshore sector for Jones Beach. The results of these calculations are presented as ray plots in Appendix I.

Bathymetry used in the wave refraction is presented in Figures 16 and 17. As discussed previously, Hudson Canyon is the most prominent feature of the offshore bathymetry. Nearshore, ridge and swales can be seen in the irregular contours. The grid coverage presented in Figure 16 for calculation of refraction is square, as required by the program.

For the 9 and 12-second waves, there is considerable longshore variability in wave refraction. Hudson Canyon and the ridge and swale systems offshore of Jones Beach affect shoaling waves at these frequencies, resulting in a non-uniform distribution of energy alongshore. Although these longer period

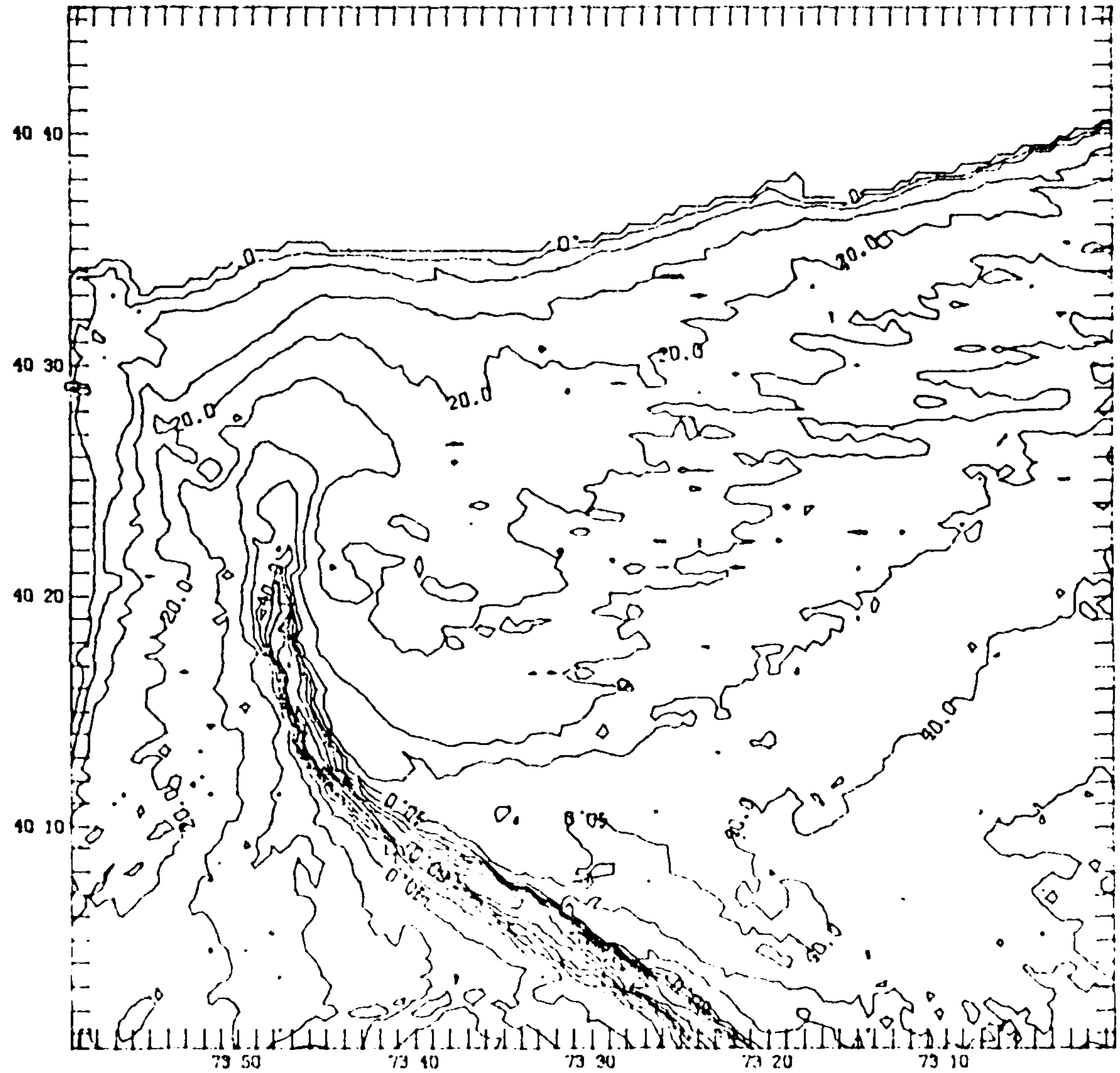

Figure 16. Offshore bathymetry for wave refraction analysis

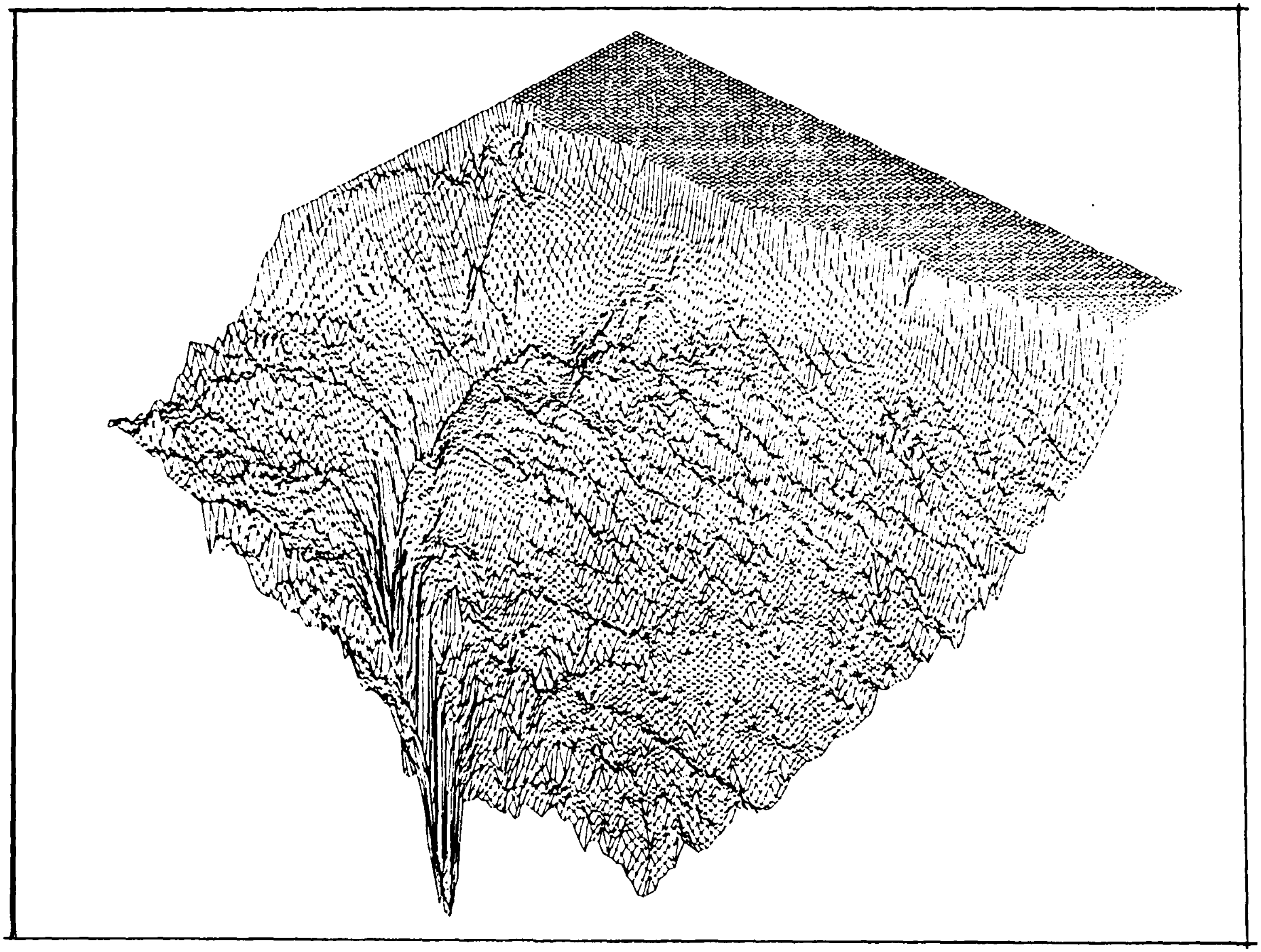

Figure 17. Three-dimensional offshore bathymetry

waves are generally divergent over the study area at large, there are some local convergences. Conversely, 6-second waves are highly uniform alongshore since they are not long enough in wavelength to be significantly affected by the variable bottom topography offshore.

2. Beach Profile Changes

Changes in beach profiles through time were quantified using three separate techniques. The four indicators of beach change are MSL volume, MSL shoreline position, and beach mean and demeaned eigenfunctions. The first two indicators were calculated by CERC and are shown in Appendixes C and D. The last were calculated as part of the present study and plots are shown as Appendixes G and H. The three indicators can be applied to a number of time scales: long-term changes ($T > 5$ years), seasonal changes (1 month $< T <$ 1 year), and short-term changes ($T < 1$ month). Natural changes are often masked or obliterated by man-made changes, such as dredging, nourishment, construction, or beachface grooming, which have occurred along Jones Beach.

a. Long-Term Changes. Above MSL volume and MSL intercept calculations (Table 2) differentiate profile lines experiencing erosion from those experiencing accretion. Lines 1, 5, and 6 span too short a period to be useful in documenting long-term trends. Six lines show significant trends (2, 14, 15, 16, 17, and 18; Figs. 18 through 32); however, only profile line 2 shows erosion (18 cubic meters per meter per year between 1974 and 1972). The other lines all show an accretional tendency as follows:

Table 2

Beach Volume and Intercept Changes

Profile Line	Above MSL Volume Slope ($m^3/m/yr$)	Above MSL Volume R^2	MSL Intercept Slope (m/yr)	MSL Intercept R^2
1*	-21.1	0.823	-7.8	0.630
2	-18.1	0.943	-11.7	0.965
3	3.1	0.016	2.2	0.060
4	-1.5	0.064	-0.6	0.036
5**	239.7	0.988	6.7	0.872
6**	-0.7	0.001	9.0	0.573
7	-3.8	0.248	-2.7	0.264
8	-0.4	0.004	0.2	0.005
9	-0.6	0.014	0.1	0.001
10	-0.6	0.015	-0.3	0.010
11	-2.3	0.172	-1.0	0.097
12	2.4	0.147	1.5	0.094
13	4.3	0.303	2.5	0.249
14	7.9	0.585	4.9	0.512
15	20.5	0.701	8.2	0.818
16	20.2	0.716	12.7	0.910
17	11.2	0.598	13.3	0.932
18	17.1	0.839	12.8	0.947

All surveys extend from 10 October 1962 through 5 June 1974 unless otherwise marked.

* October 1962 - March 1966
** June 1966 - October 1966

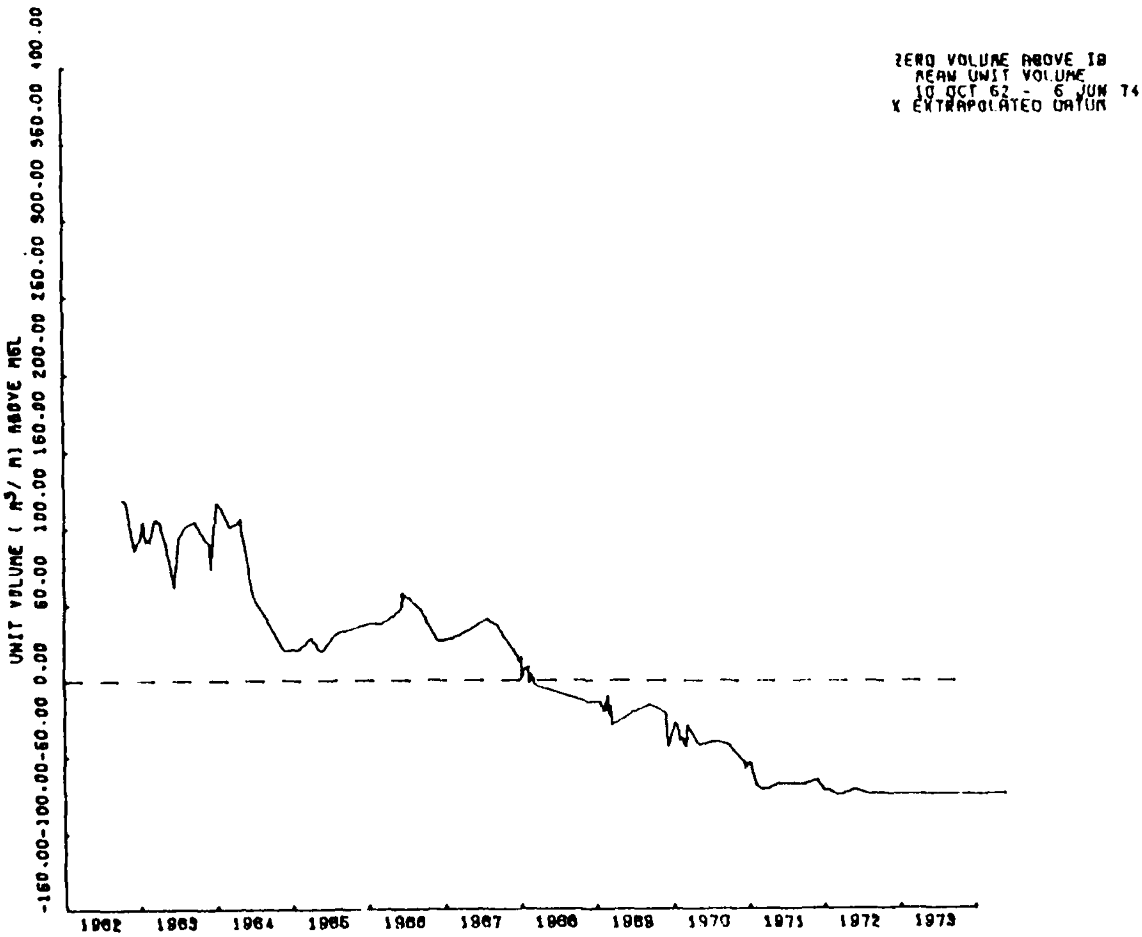

Figure 18. Unit volume changes for profile line 2 at Jones Beach, New York

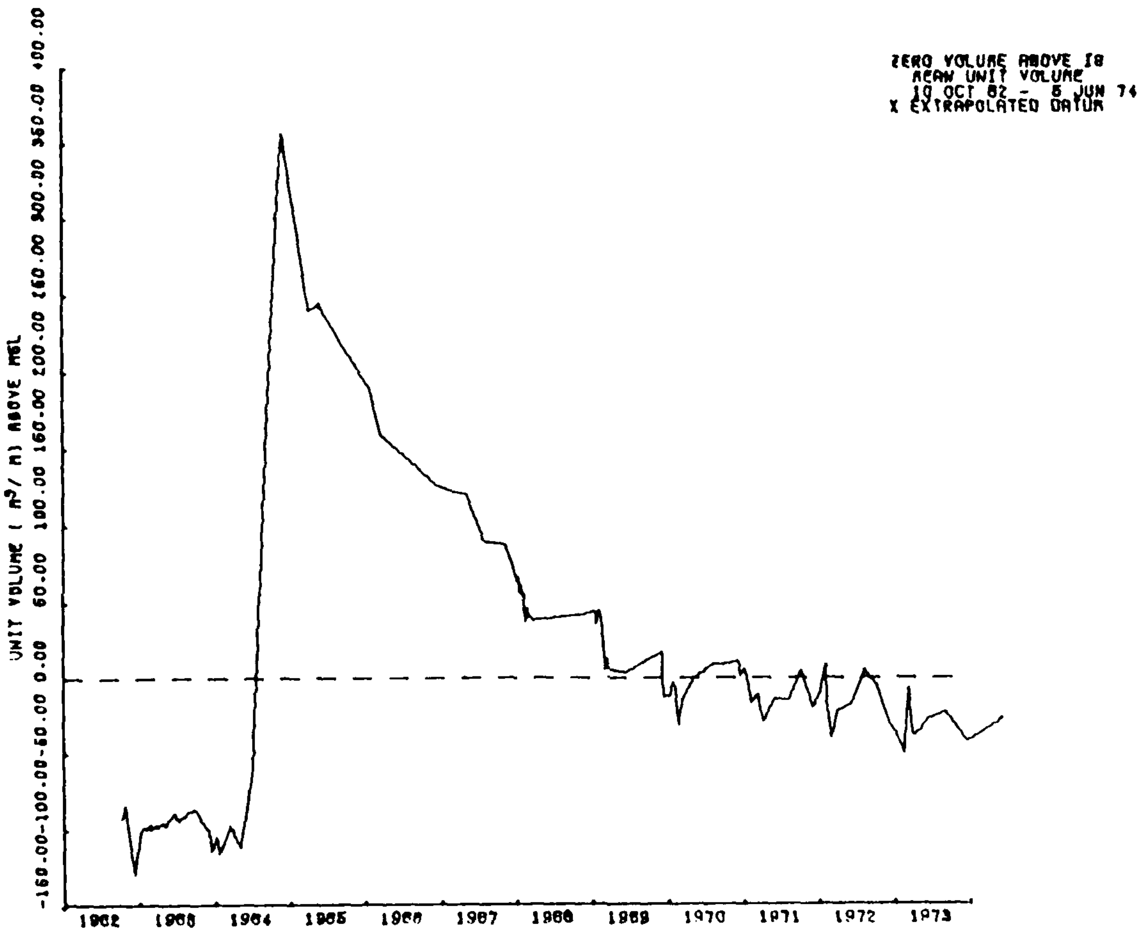

Figure 19. Unit volume changes for profile line 3 at Jones Beach, New York

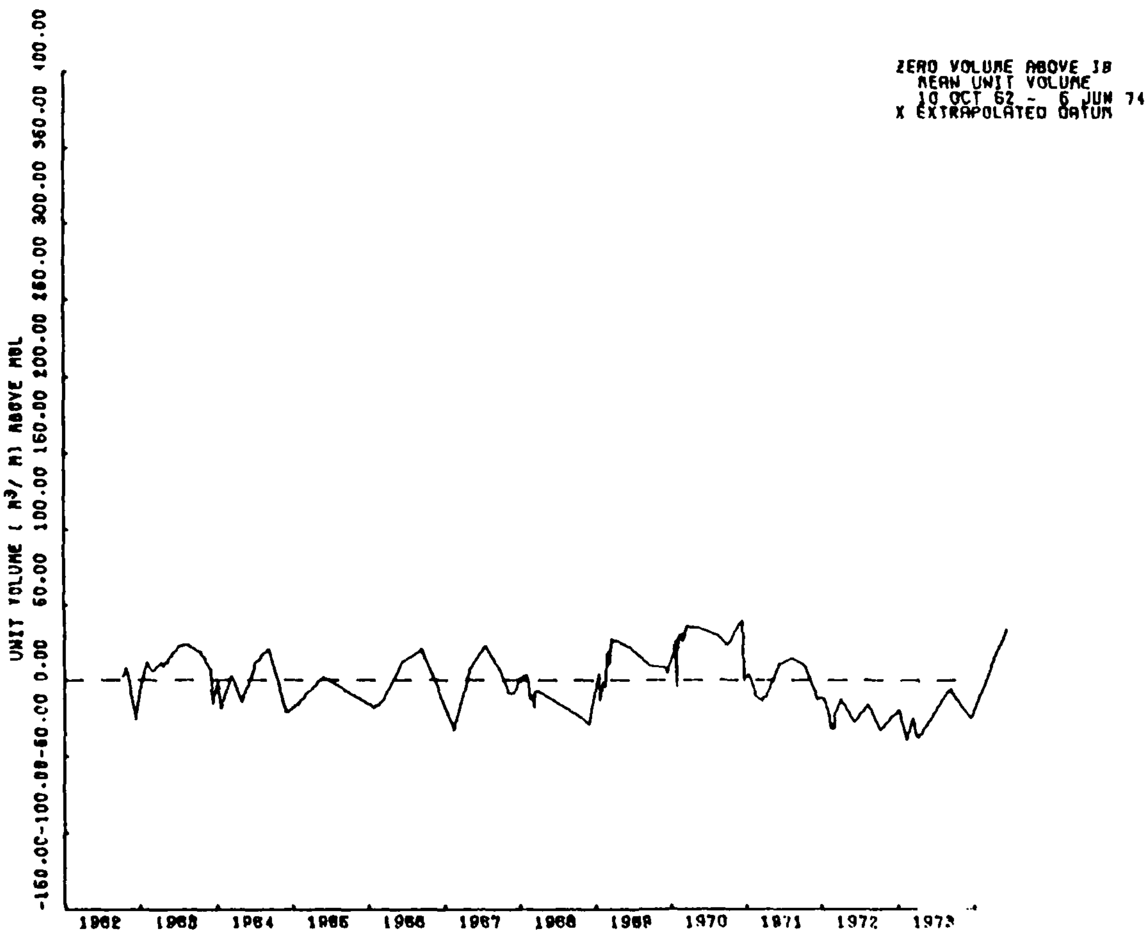

Figure 20. Unit volume changes for profile line 4 at Jones Beach, New York

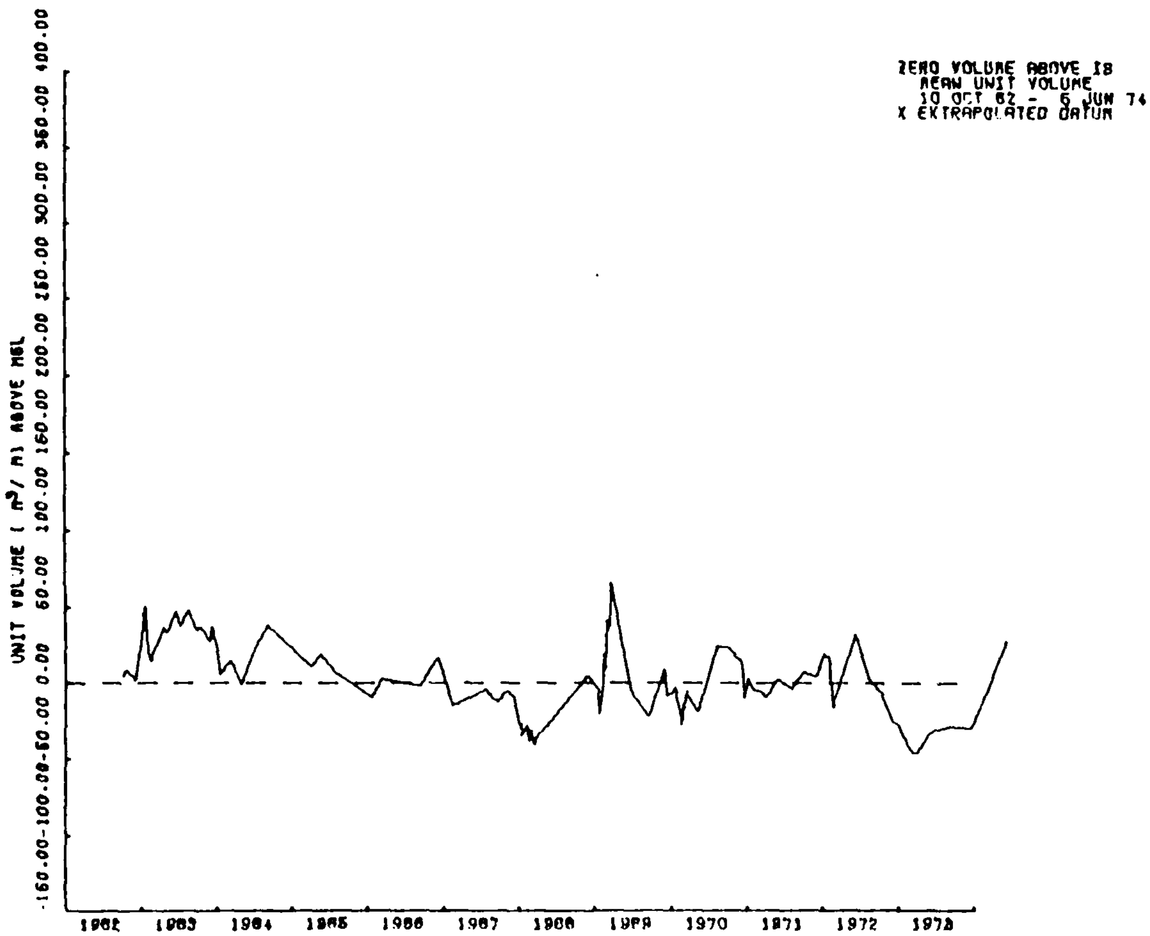

Figure 21. Unit volume changes for profile
line 7 at Jones Beach, New York

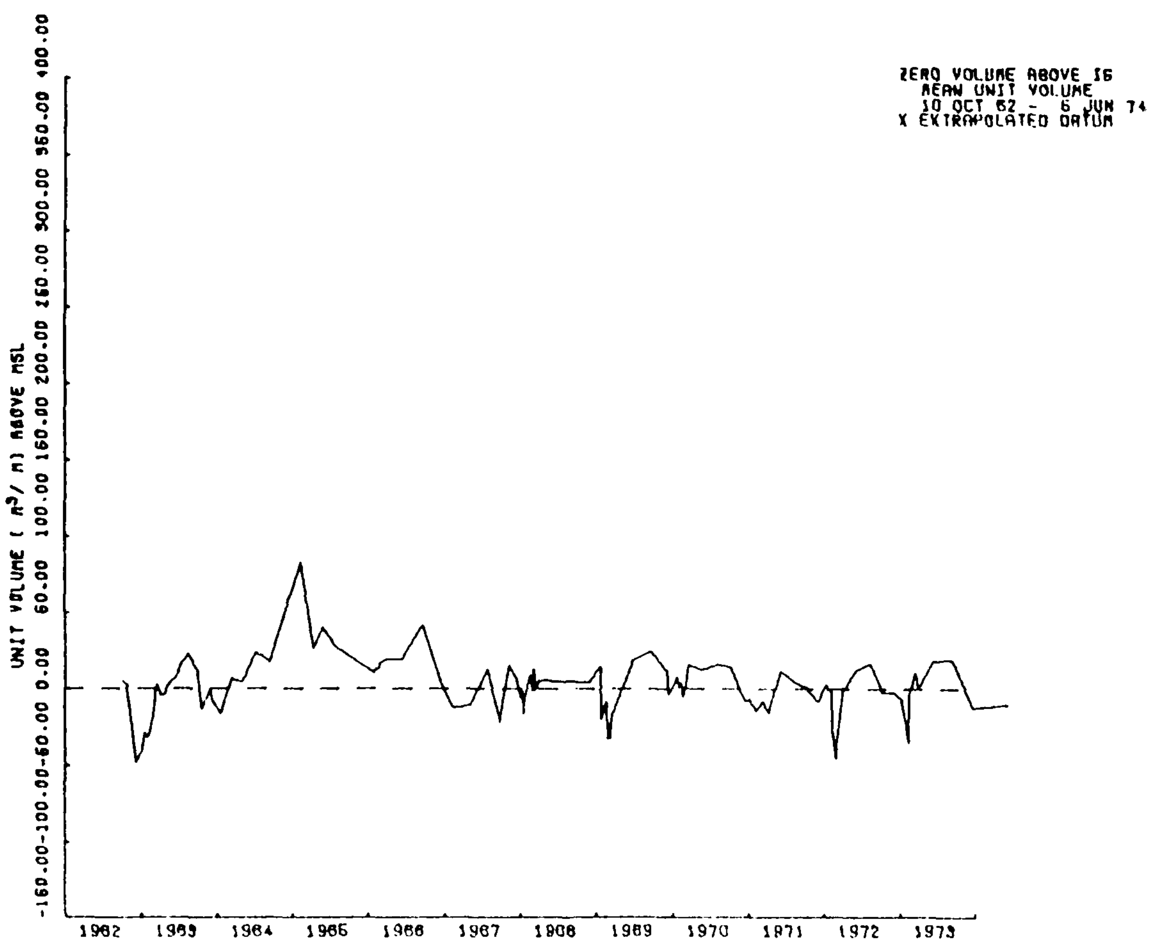

Figure 22. Unit volume changes for profile line 8 at Jones Beach, New York

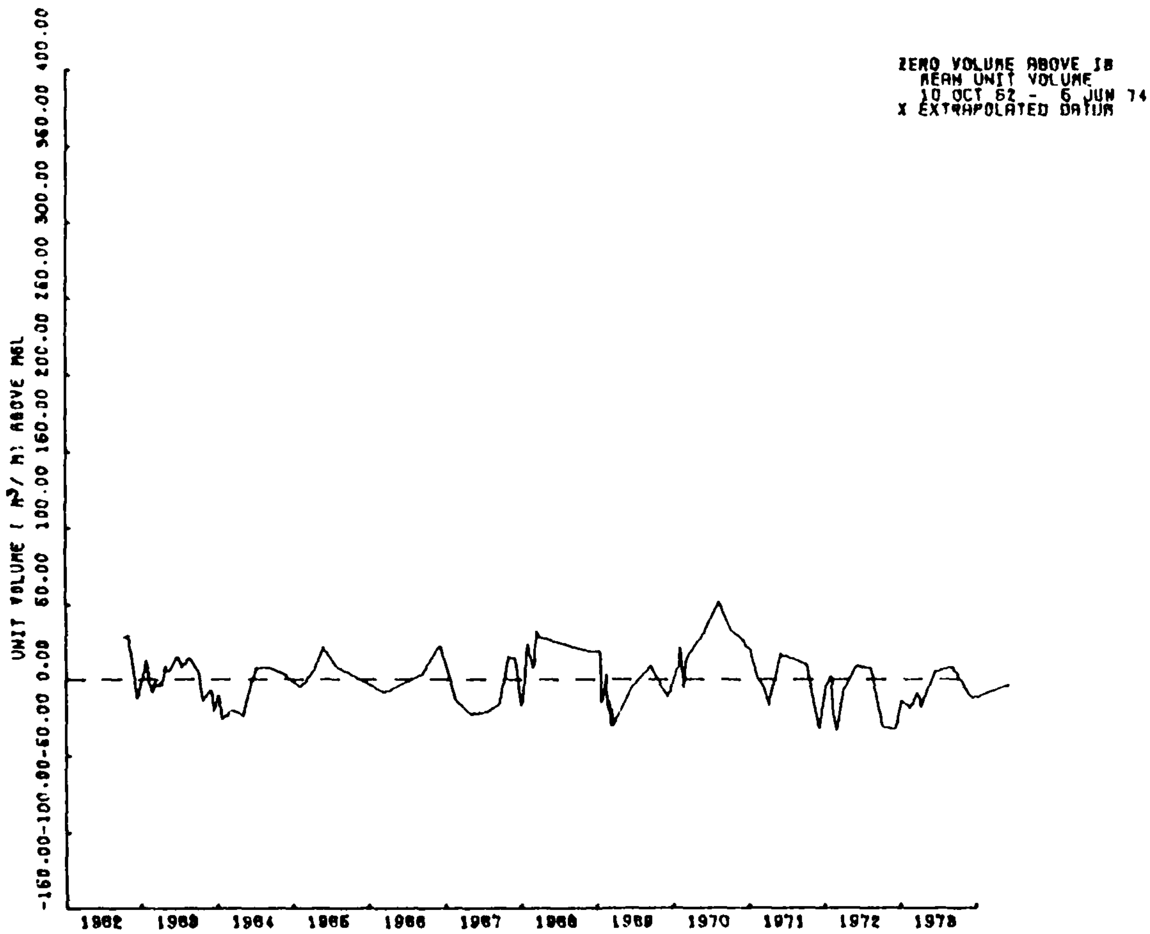

Figure 23. Unit volume changes for profile line 9 at Jones Beach, New York

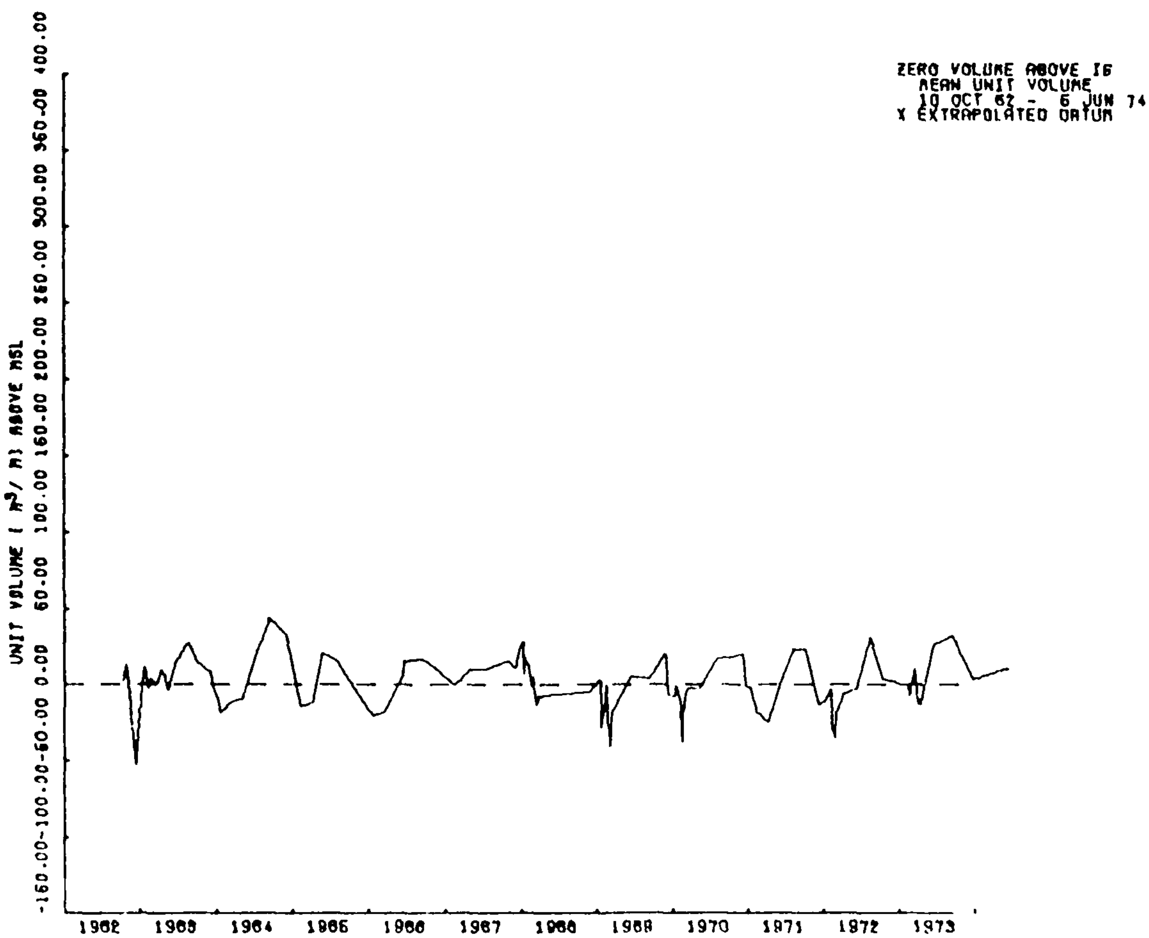

Figure 24. Unit volume changes for profile
line 10 at Jones Beach, New York

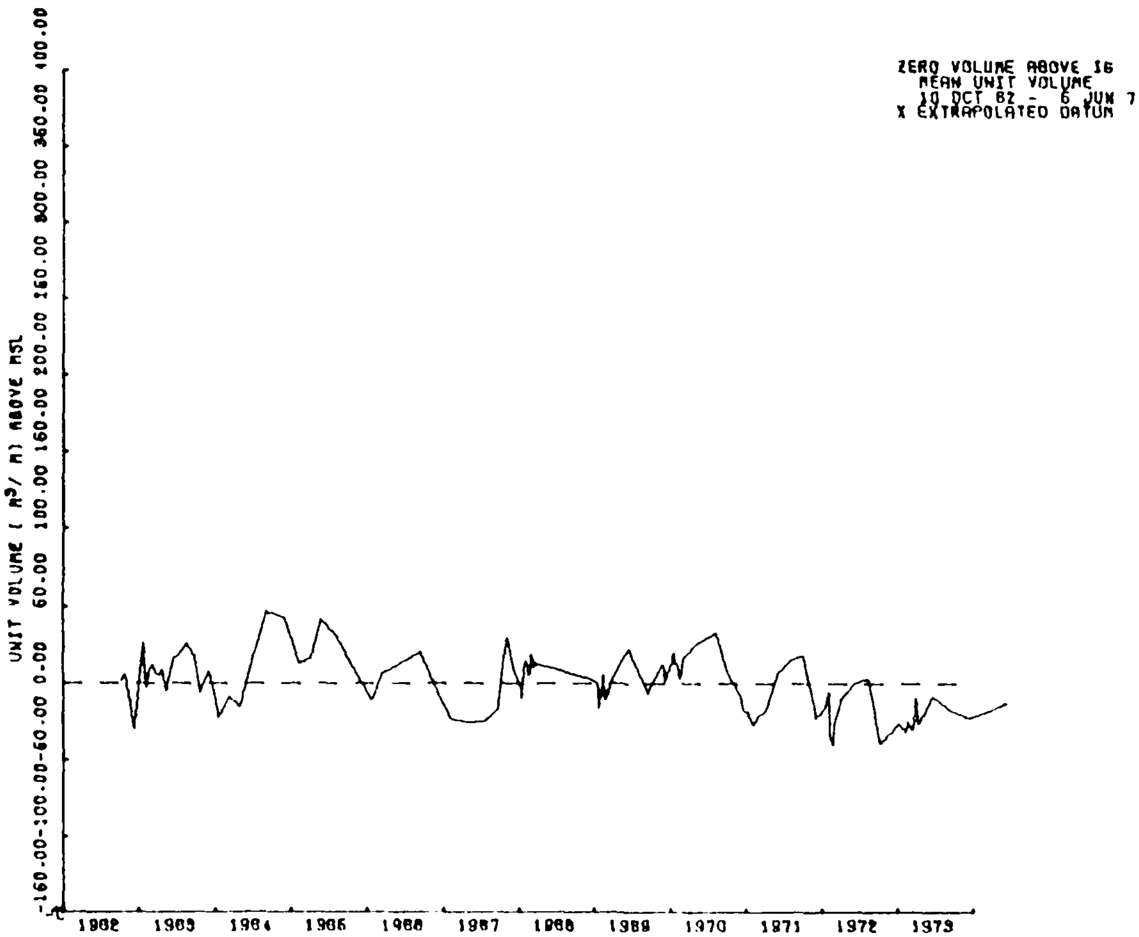

Figure 25. Unit volume changes for profile line 11 at Jones Beach, New York

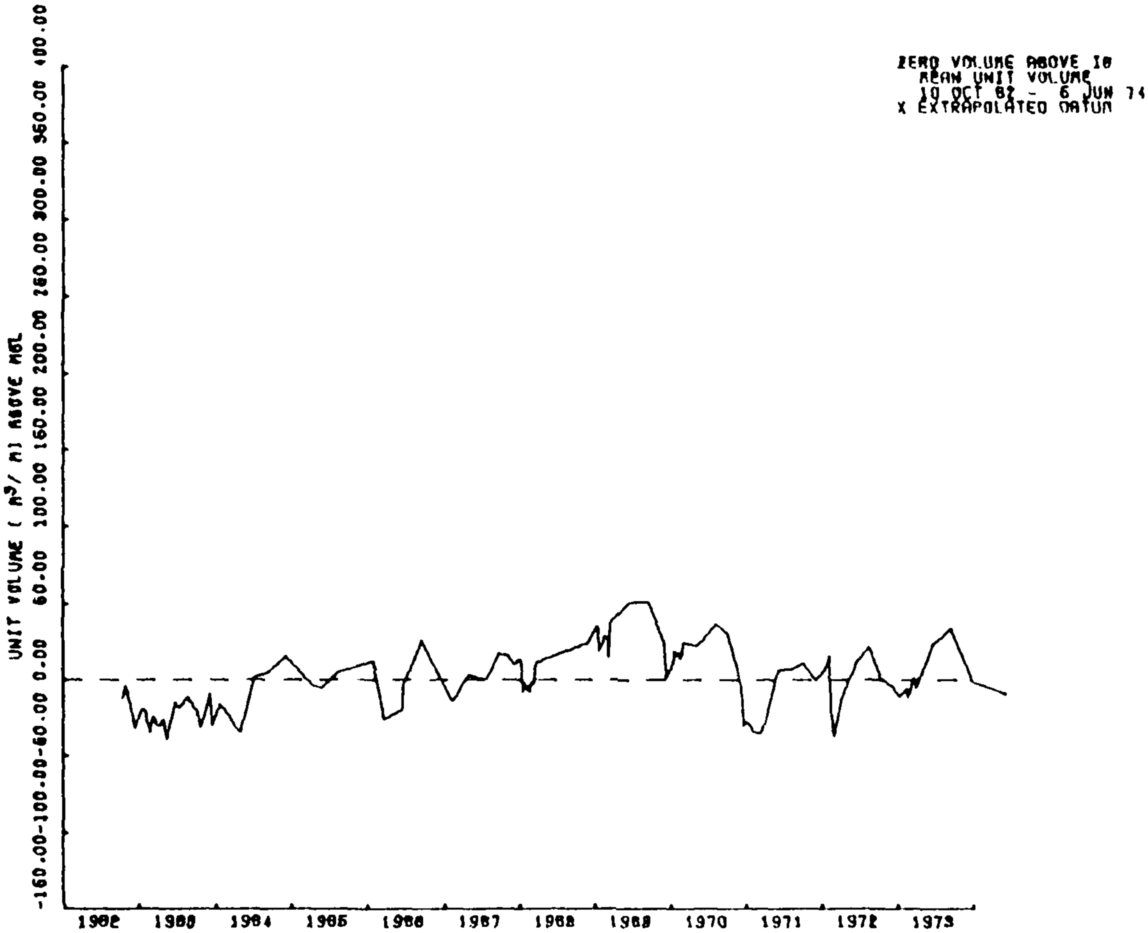

Figure 26. Unit volume changes for profile line 12 at Jones Beach, New York

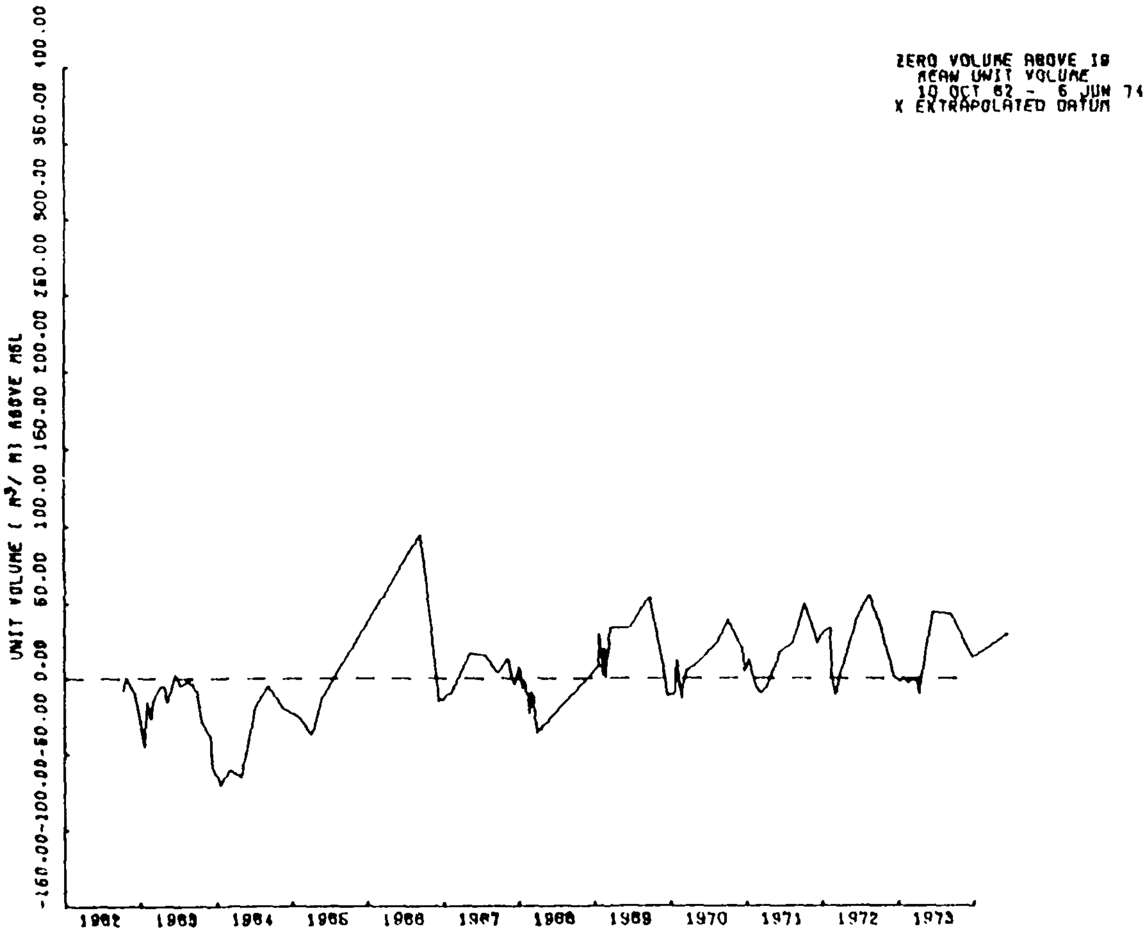

Figure 27. Unit volume changes for profile line 13 at Jones Beach, New York

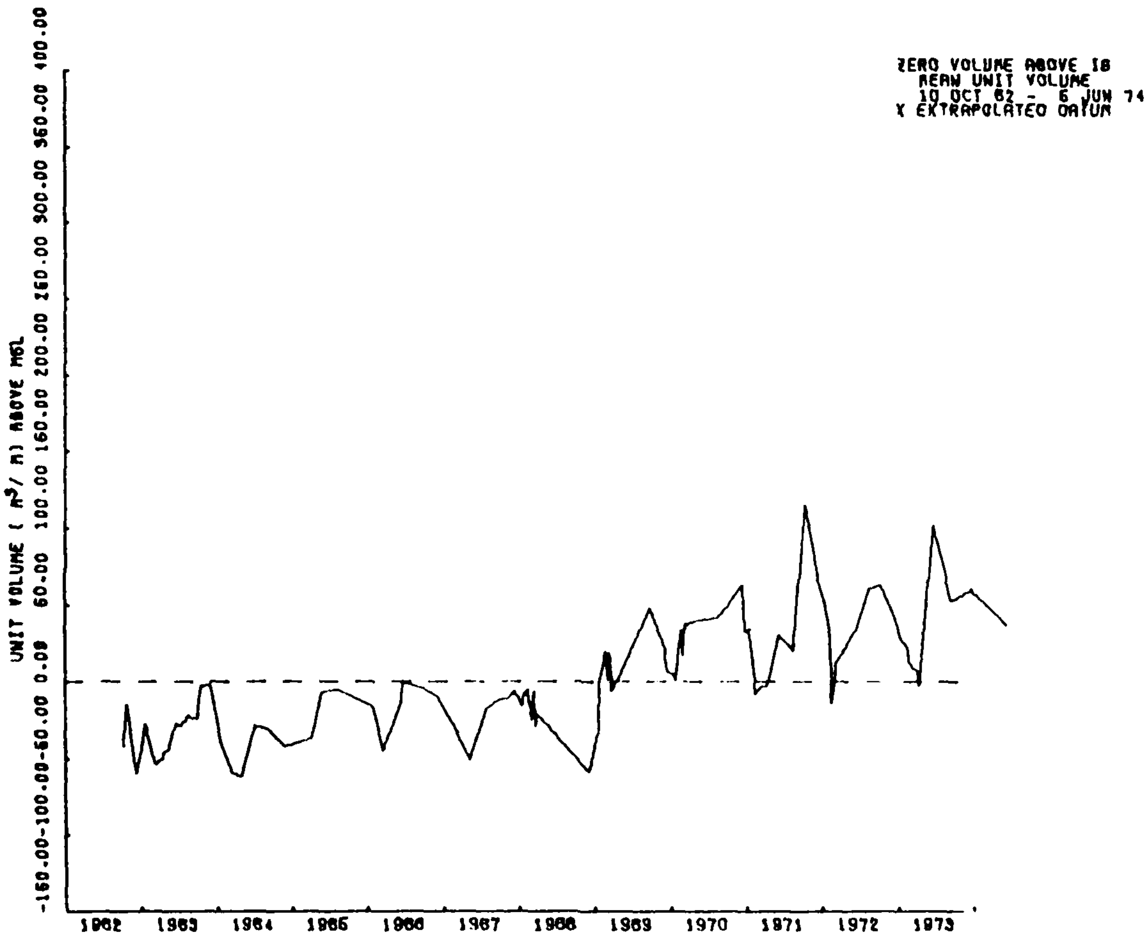

Figure 28. Unit volume changes for profile line 14 at Jones Beach, New York

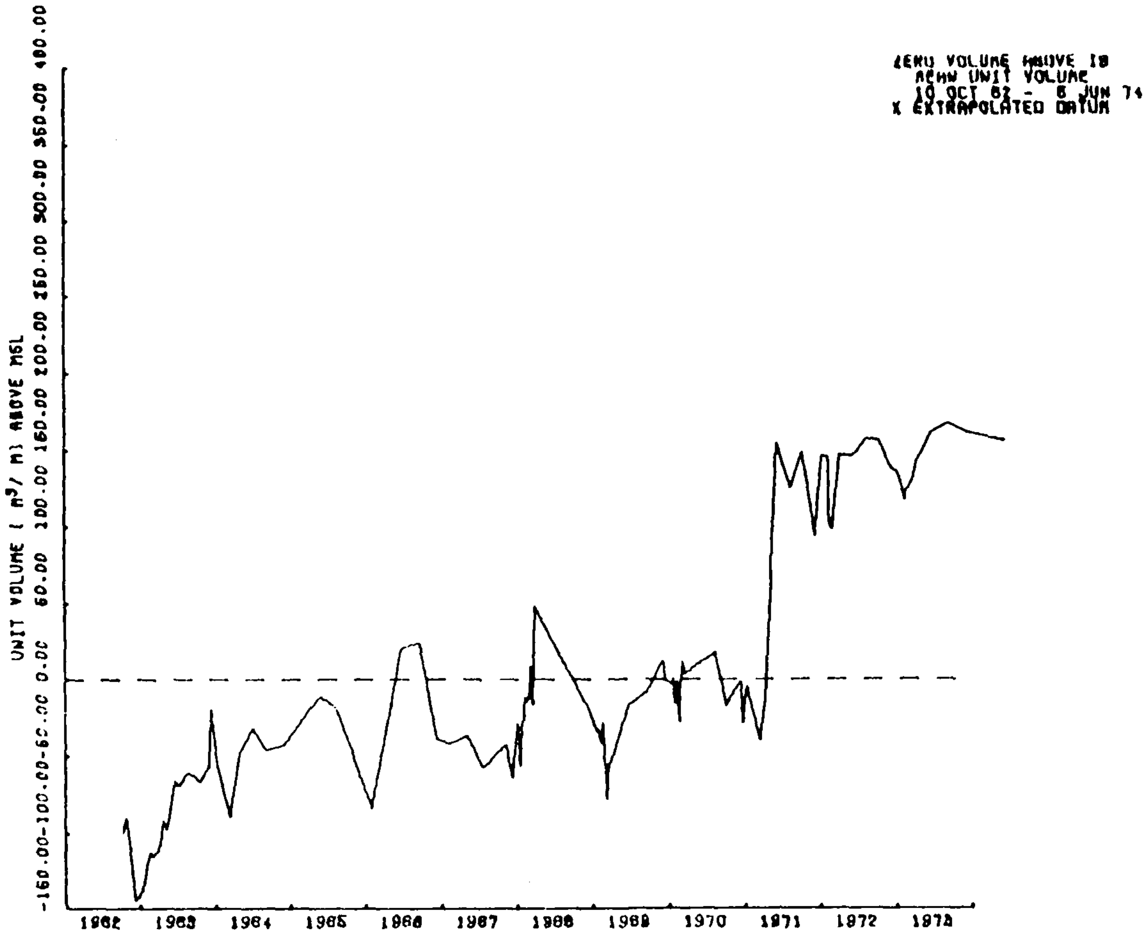

Figure 29. Unit volume changes for profile line 15 at Jones Beach, New York

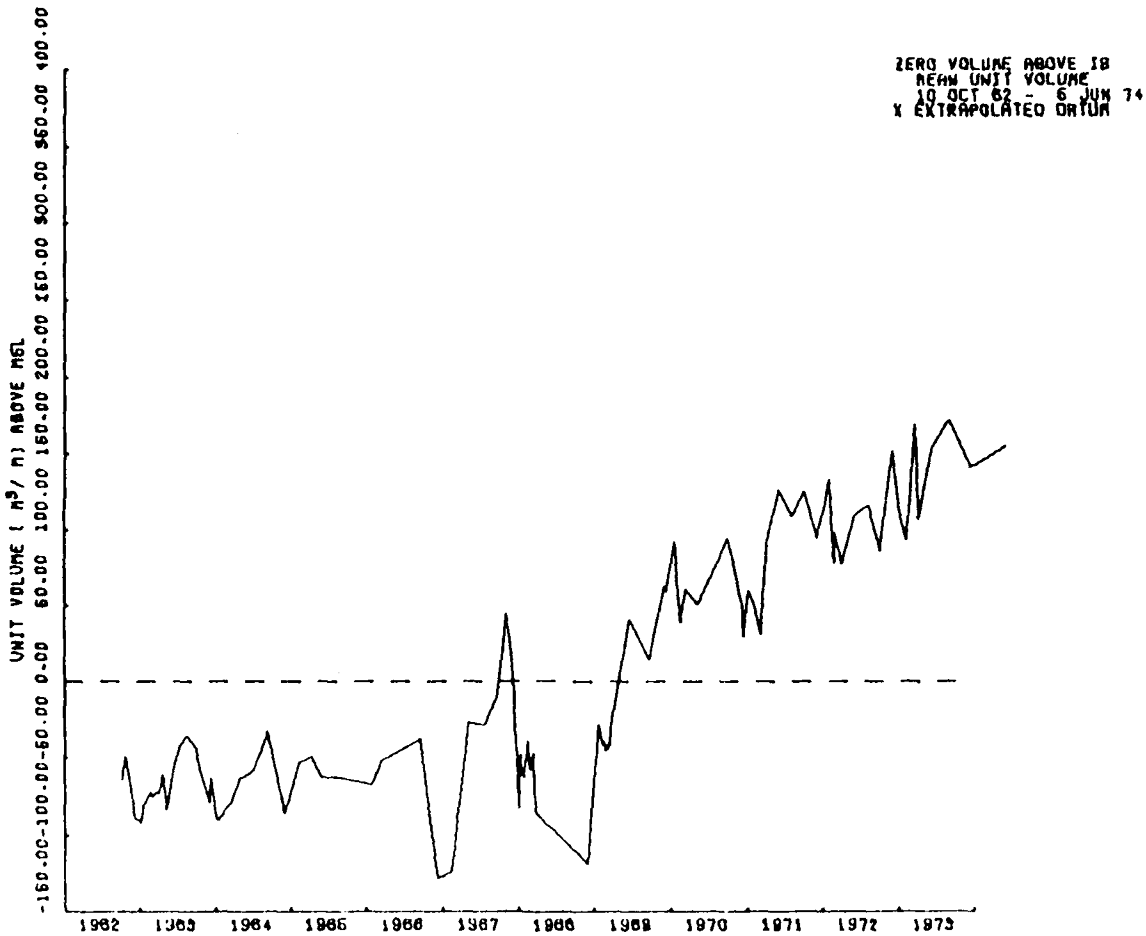

Figure 30. Unit volume changes for profile line 16 at Jones Beach, New York

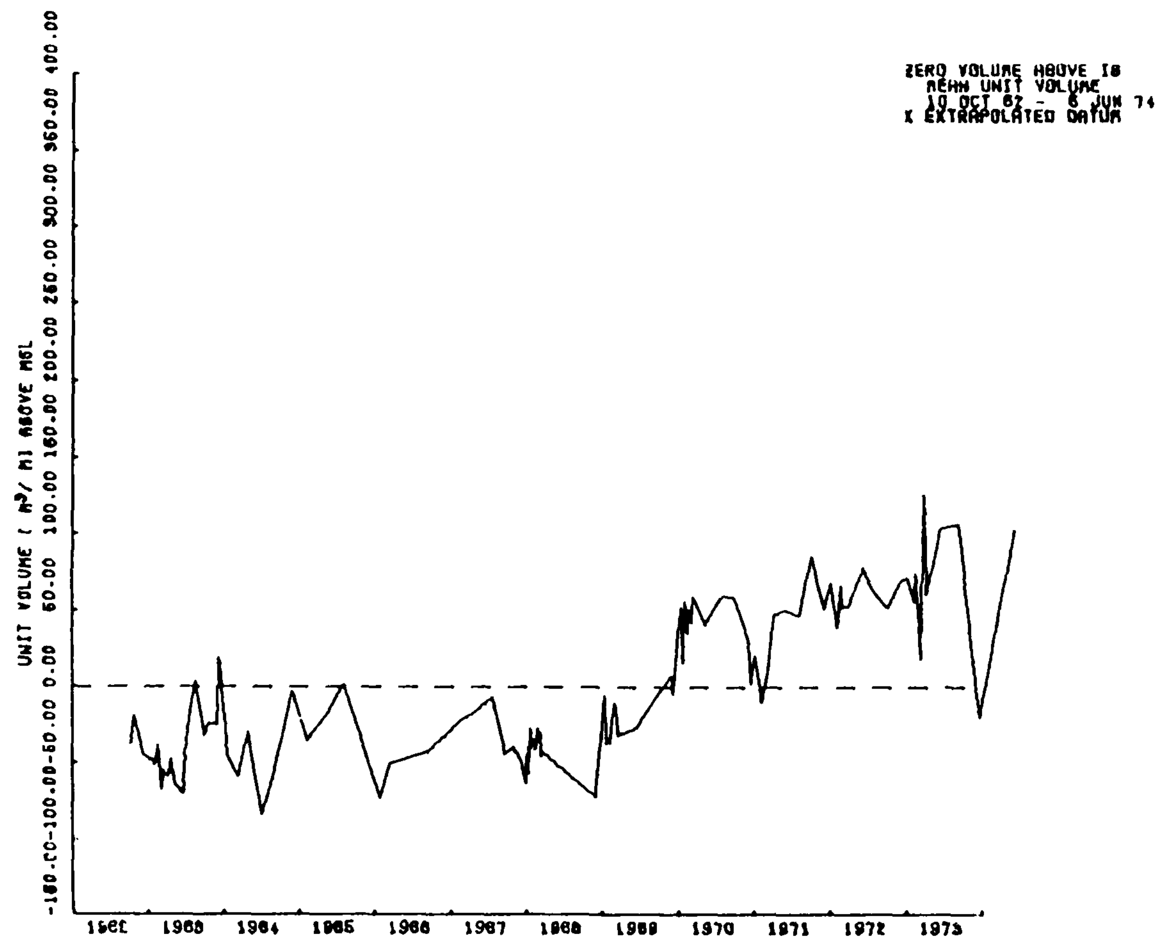

Figure 31. Unit volume changes for profile line 17 at Jones Beach, New York

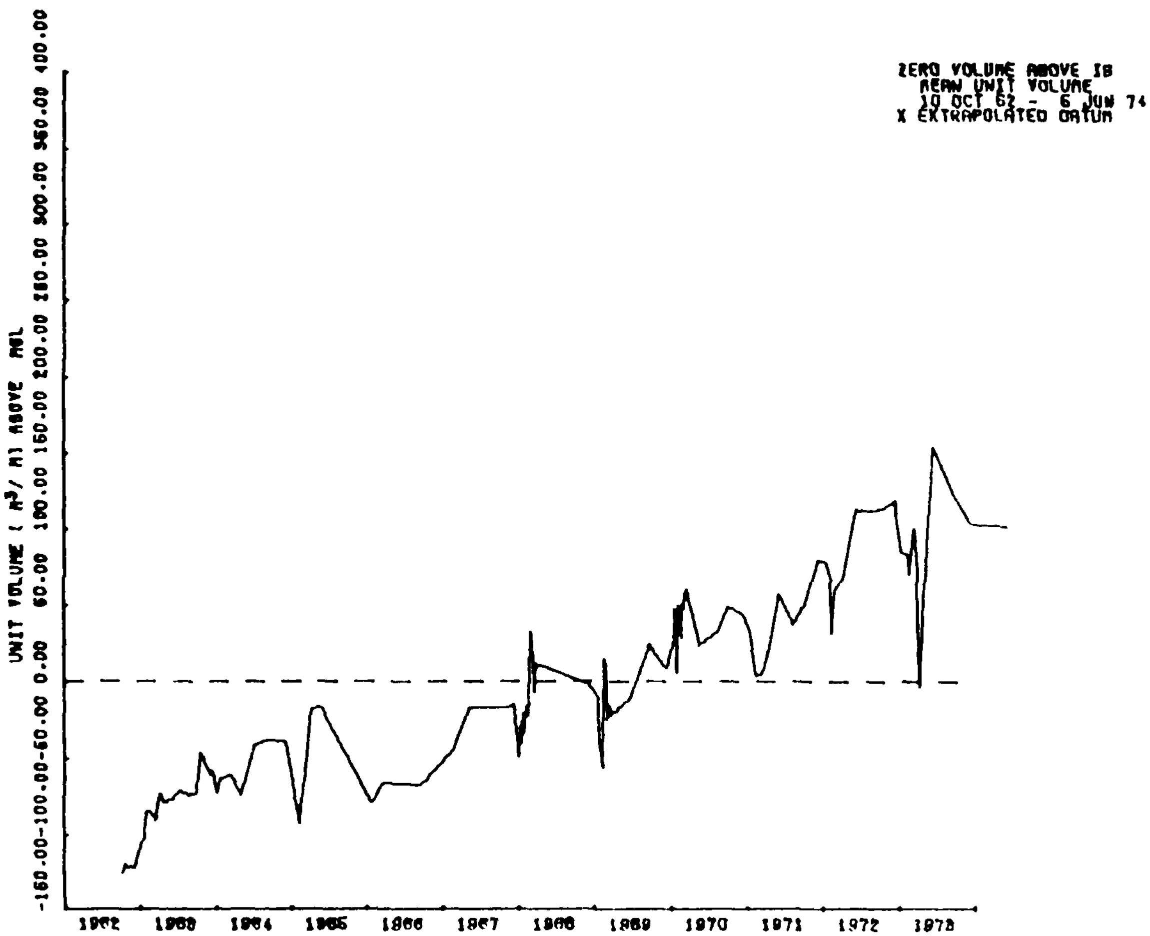

Figure 32. Unit volume changes for profile line 18 at Jones Beach, New York

- line 14 - 8 cubic meters per meter per year
- line 15 - 21 cubic meters per meter per year
- line 16 - 20 cubic meters per meter per year
- line 17 - 11 cubic meters per meter per year
- line 18 - 17 cubic meters per meter per year

These trends are substantiated by trends in MSL-intercept (Appendix D), a condition not found in studies of other east coast beaches (Morton et al., 1983).

Similar long-term trends in profile development can be observed from results of eigenfunction analysis (Table 3). Profile line 2 shows erosion over the period of study (Fig. 33). Profile line 3 has a large input of material between April 1964 and September 1964, followed by a gradual loss of sediment from the beach through 1974 (Fig. 34). Profile line 4 shows a slight loss of sediment, which is masked by larger, higher frequency fluctuations (Fig. 35). Profile line 7 shows a trend similar to that of line 4 (Fig. 36). Profile lines 8 and 9 show no definite long-term erosional or accretionary trends (Figs. 37 and 38). Profile line 10 shows accretion in the beachshore and erosion in the foreshore (Fig. 39). Profile line 11 shows a small erosion (Fig. 40), while the adjacent profile lines 12 and 13 show no trend over the period of study (Figs. 41 and 42). Profile line 14 shows a slight accretion over the 12-year period (Fig. 43). Line 15 shows little trend over most of the study (Fig. 44); however between April 1971 and June 1971 there was a sizeable addition of sand to the beach. From 1971 through 1974 there was a slight loss of sand from the June 1971 level. Profile line 16 shows little trend, with the exception of the period from March 1969 to June

Table 3

Beach Eigenfunction Summary

		Mean Included			Demeaned	
Profile Line	Eigenfunction No.	(m^2) MSV	% Total MSV	% Residual	(m^2) MSV	% Total MSV
2	Total	4.66			0.858	
	1	3.96	85.1		0.659	76.8
	2	0.57	12.3	82.8	0.142	16.5
	3	0.07	1.5	10.1	0.025	2.9
	4	0.02	0.5	3.1	0.074	0.9
3	Total	15.25			0.391	
	1	15.00	98.1		0.329	84.0
	2	0.229	1.5	80.0	0.029	7.3
	3	0.028	0.2	9.8	0.011	2.7
	4	0.010	0.1	3.3	0.008	2.1
4	Total	15.80			0.321	
	1	15.60	98.4		0.183	57.0
	2	0.128	0.8	51.8	0.064	19.8
	3	0.062	0.4	25.3	0.024	7.5
	4	0.022	0.1	8.9	0.020	6.1
7	Total	11.85			0.348	
	1	11.50	97.4		0.179	51.4
	2	0.157	1.3	51.4	0.052	15.1
	3	0.047	0.4	15.5	0.034	9.7
	4	0.025	0.2	8.1	0.025	7.1
8	Total	15.85			0.174	
	1	15.70	99.0		0.083	47.7
	2	0.080	0.5	51.8	0.033	18.7
	3	0.027	0.2	17.6	0.024	14.0
	4	0.016	0.1	10.3	0.014	8.0
9	Total	8.73			0.185	
	1	8.57	98.1		0.076	41.4
	2	0.065	0.7	38.8	0.038	20.7
	3	0.038	0.4	22.8	0.026	13.8
	4	0.025	0.3	15.1	0.017	9.2
10	Total	8.83			0.184	
	1	8.68	98.4		0.074	40.4
	2	0.070	0.8	49.8	0.048	26.4
	3	0.023	0.3	16.5	0.023	12.3
	4	0.015	0.2	10.6	0.013	7.0

(Continued)

Table 3 (Continued)

Profile Line	Eigenfunction No.	Mean Included: (m^2) MSV	Mean Included: % Total MSV	Mean Included: % Residual	Demeaned: (m^2) MSV	Demeaned: % Total MSV
11	Total	10.80			0.285	
	1	10.6	98.3		0.158	55.3
	2	0.075	0.7	41.4	0.056	19.7
	3	0.042	0.4	22.9	0.031	10.8
	4	0.029	0.3	16.0	0.013	4.6
12	Total	7.49			0.125	
	1	7.38	98.7	55.5	0.073	58.8
	2	0.056	0.8	20.2	0.021	17.1
	3	0.021	0.3	11.6	0.013	10.7
	4	0.012	0.2	4.6	0.005	4.0
13	Total	7.19			0.164	
	1	7.06	98.2		0.096	58.2
	2	0.072	1.0	55.1	0.025	15.1
	3	0.024	0.3	18.7	0.014	8.8
	4	0.011	0.2	8.6	0.008	5.0
14	Total	6.86			0.096	
	1	6.78	98.8		0.051	53.0
	2	0.048	0.7	56.1	0.015	15.4
	3	0.013	0.2	15.3	0.010	10.2
	4	0.007	0.1	7.9	0.004	4.5
15	Total	9.76			0.309	
	1	9.60	98.4		0.242	78.4
	2	0.106	1.1	66.4	0.038	12.4
	3	0.031	0.3	19.2	0.012	4.0
	4	0.010	0.1	6.1	0.045	1.5
16	Total	7.70			0.196	
	1	7.53	97.8		0.099	50.2
	2	0.084	1.1	49.8	0.046	23.6
	3	0.041	0.5	24.1	0.016	8.3
	4	0.016	0.2	9.3	0.013	6.5
17	Total	5.79			0.153	
	1	5.67	97.9		0.093	61.0
	2	0.072	1.3	59.1	0.024	15.6
	3	0.022	0.4	18.1	0.010	6.3
	4	0.007	0.1	5.5	0.005	3.4

(Continued)

Table 3 (Concluded)

Profile Line	Eigenfunction No.	Mean Included (m^2) MSV	Mean Included % Total MSV	Mean Included % Residual	Demeaned (m^2) MSV	Demeaned % Total MSV
18	Total	9.39			0.550	
	1	9.07	96.6		0.491	89.3
	2	0.273	2.9	85.6	0.026	4.7
	3	0.024	0.3	7.6	0.012	2.2
	4	0.007	0.1	2.2	0.007	1.3

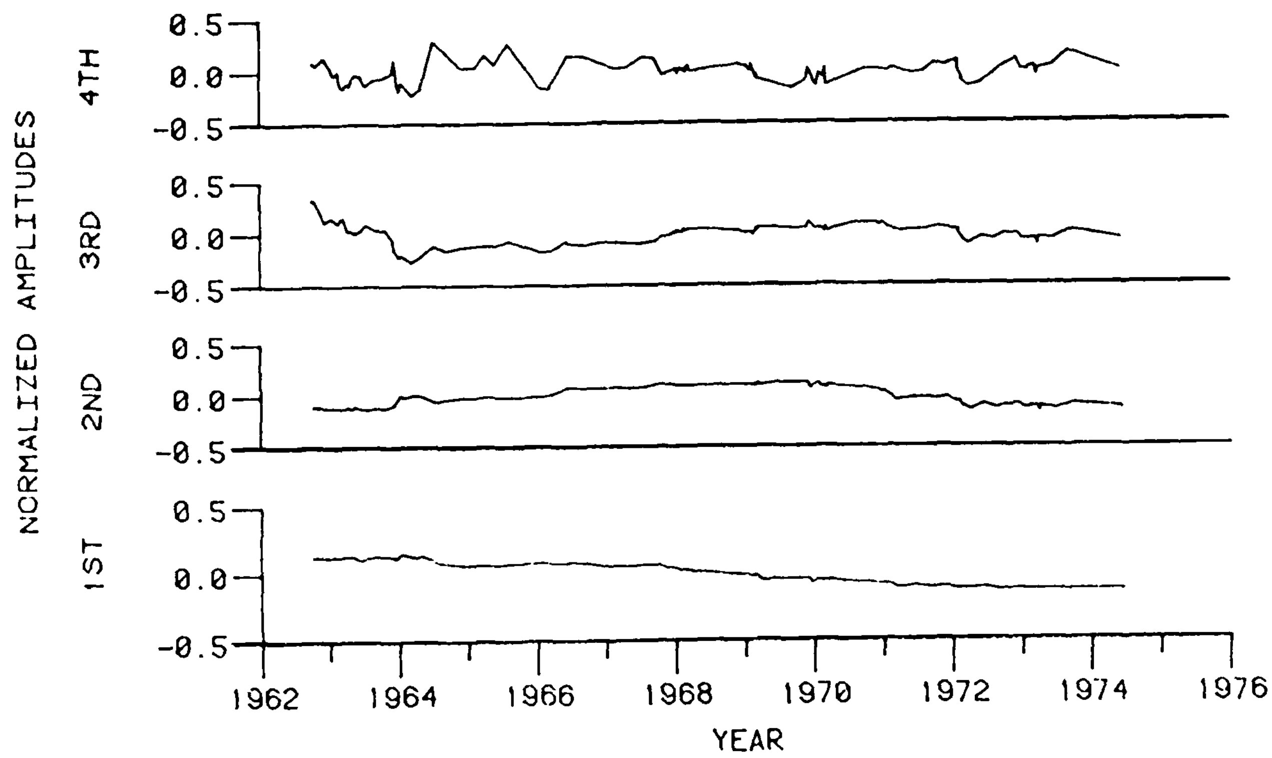

Figure 33. Temporal eigenfunctions demeaned, profile line 2

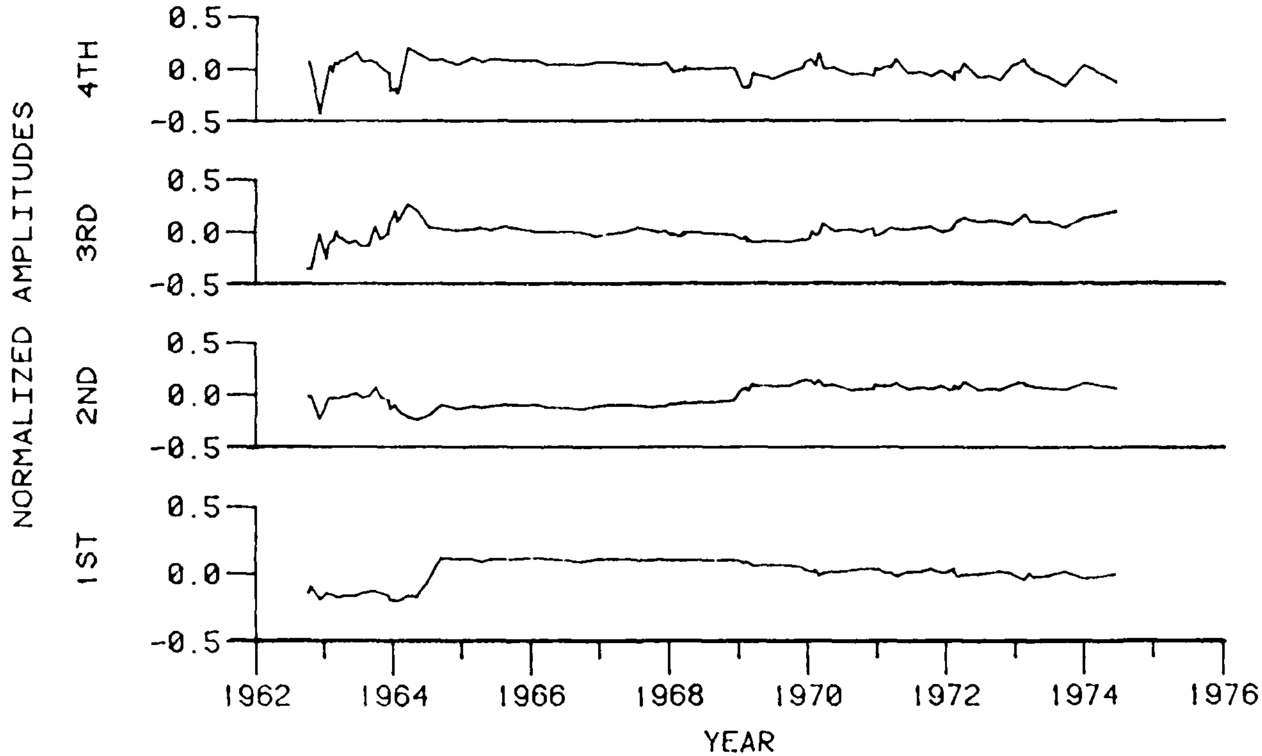

Figure 34. Temporal eigenfunctions demeaned, profile line 3

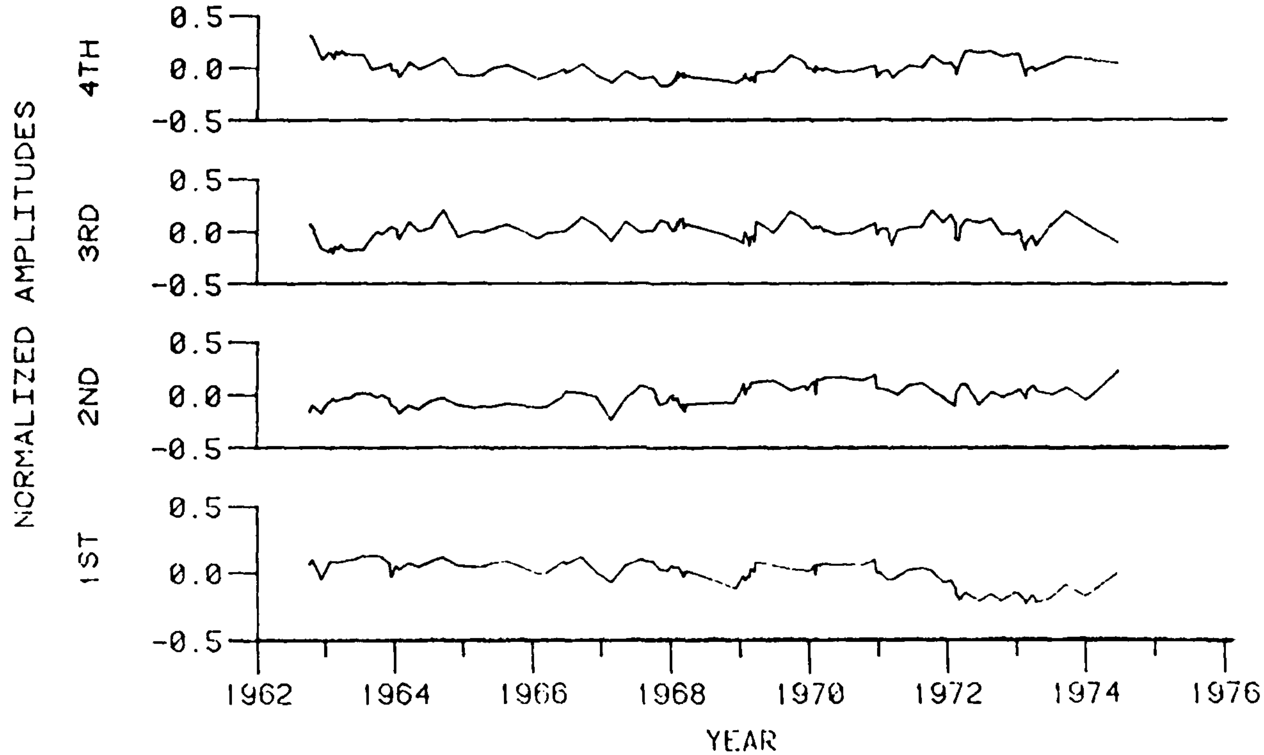

Figure 35. Temporal eigenfunctions demeaned, profile line 4

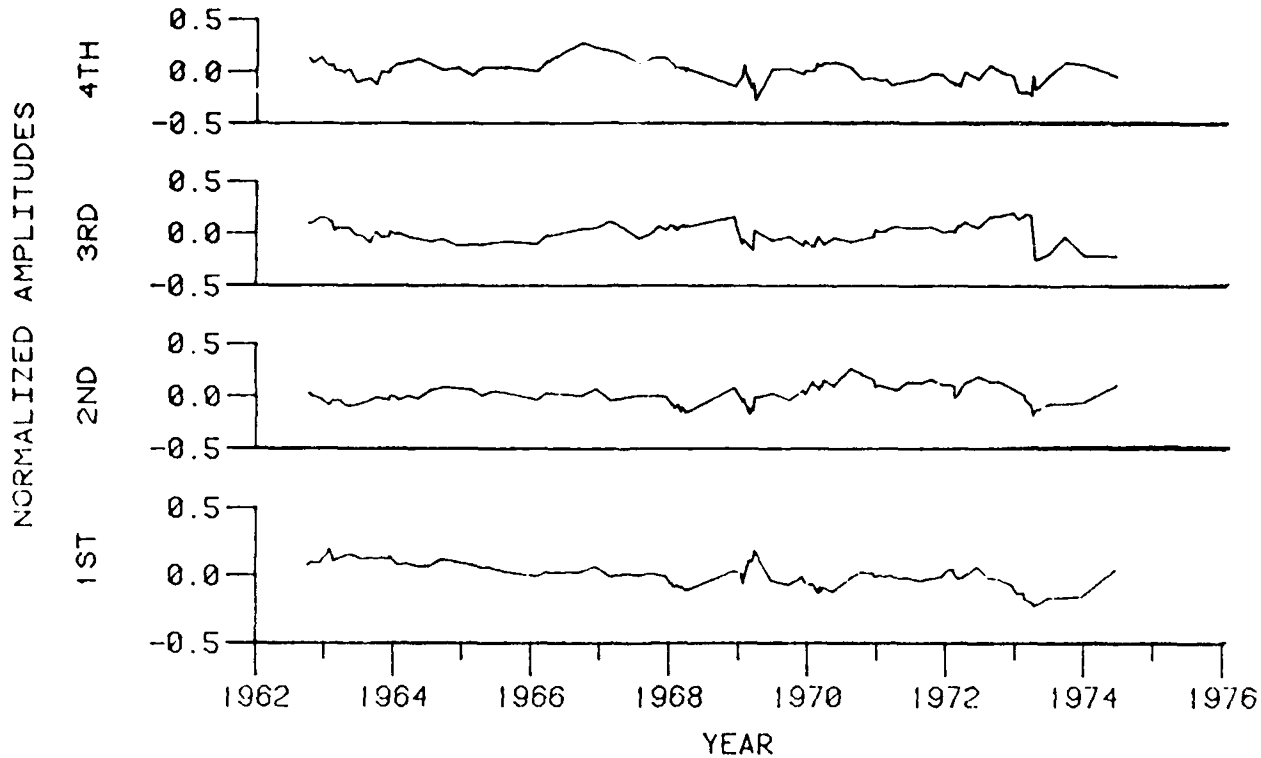

Figure 36. Temporal eigenfunctions demeaned, profile line 7

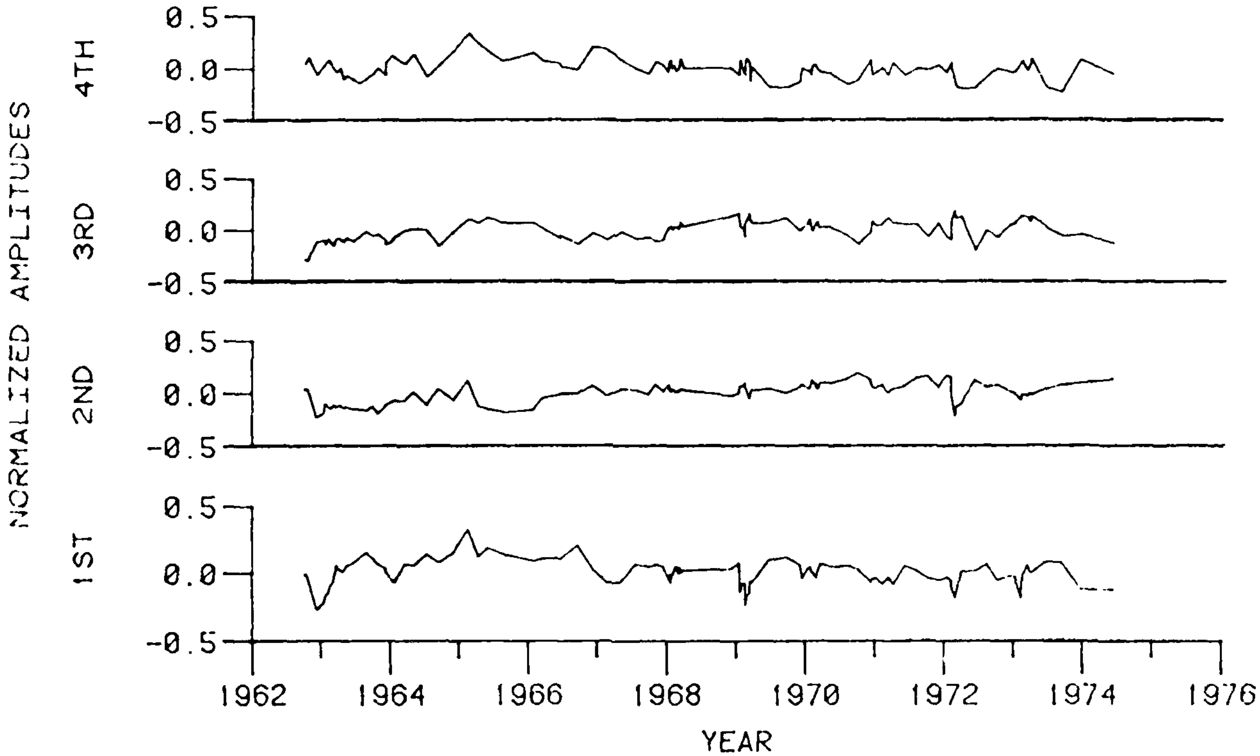

Figure 37. Temporal eigenfunctions demeaned, profile line 8

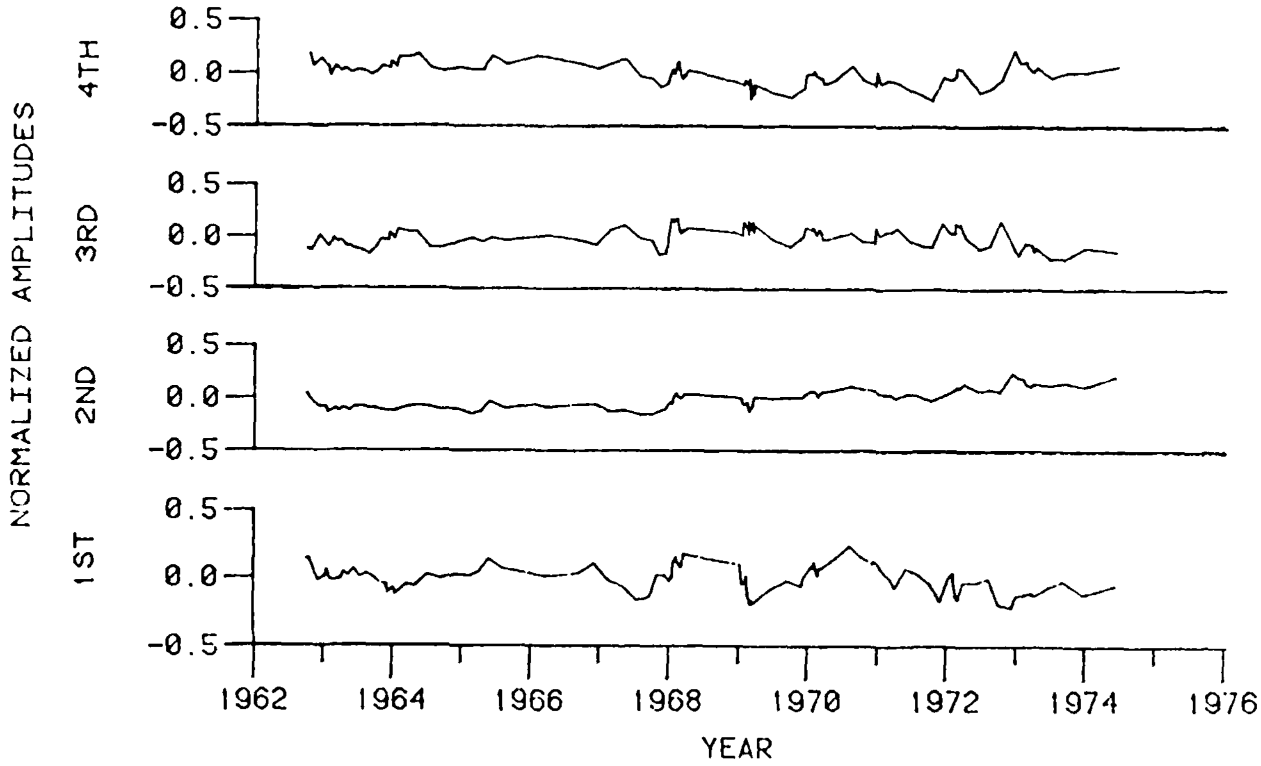

Figure 38. Temporal eigenfunctions demeaned. profile line 9

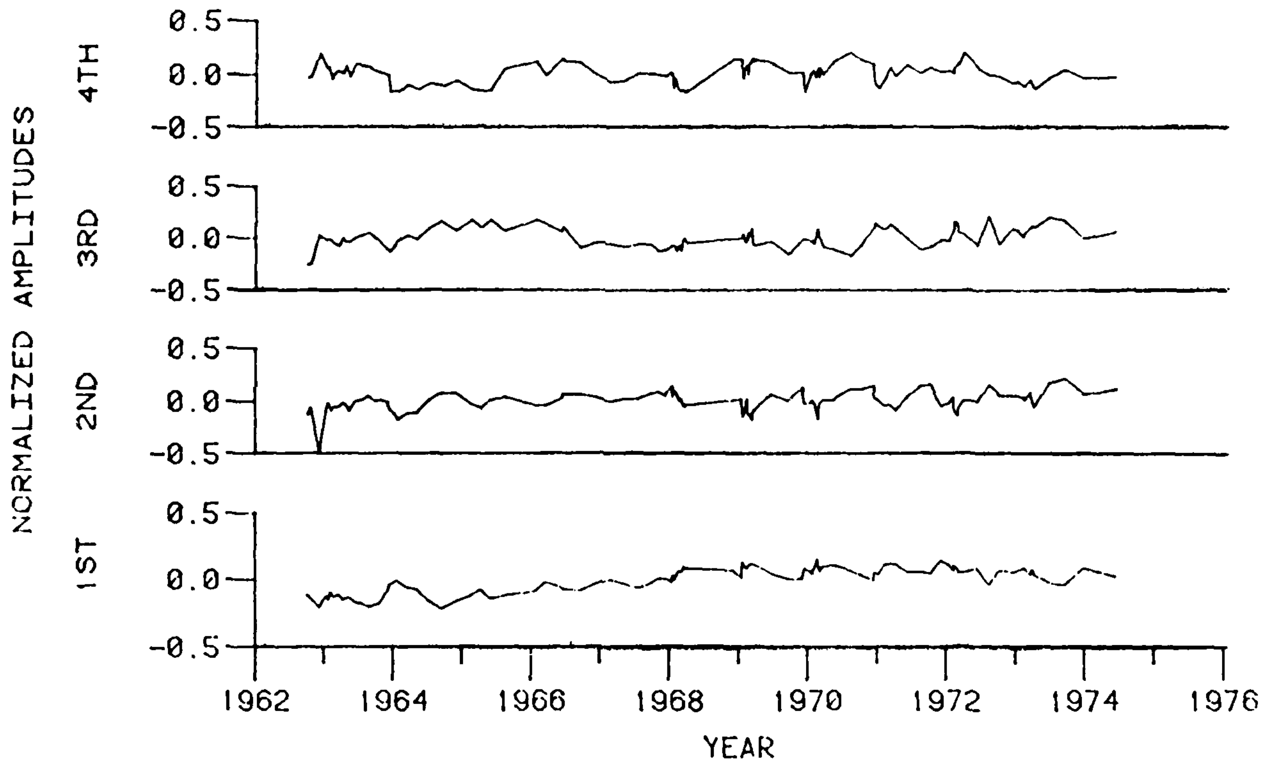

Figure 39. Temporal eigenfunctions demeaned, profile line 10

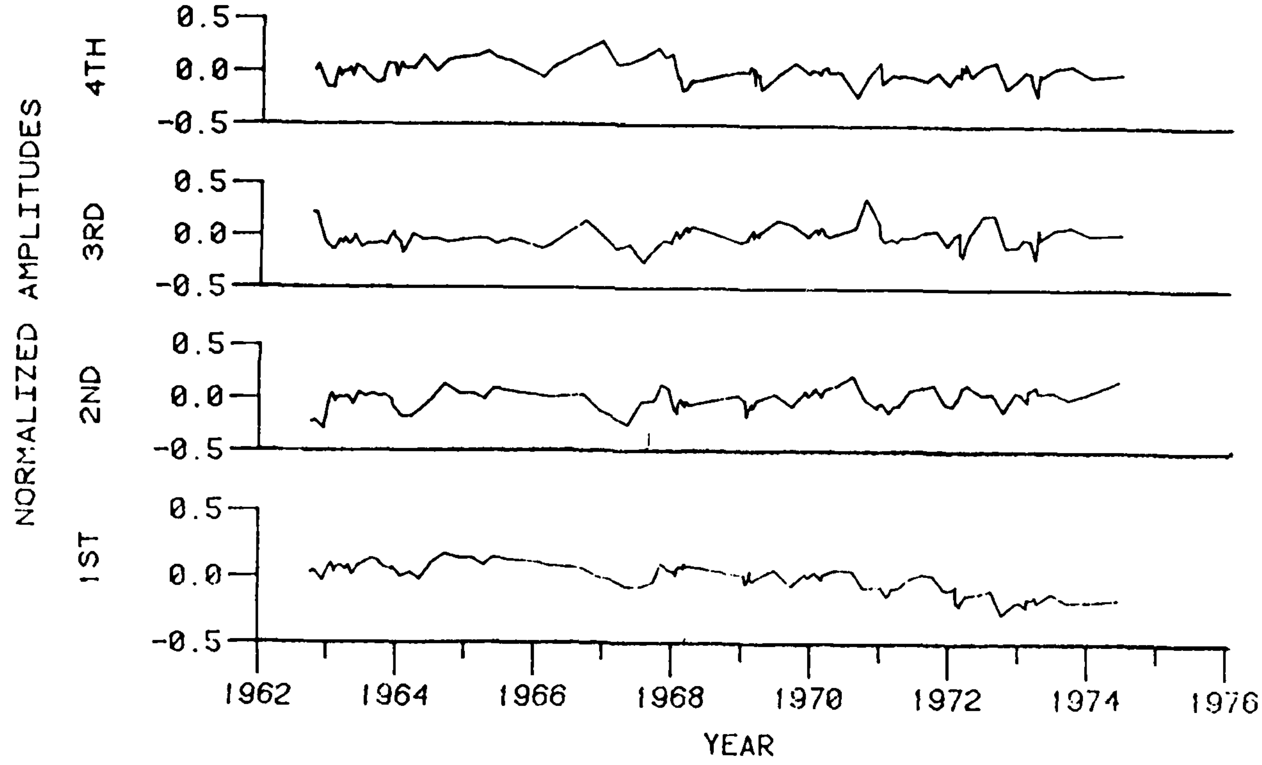

Figure 40. Temporal eigenfunctions demeaned, profile line 11

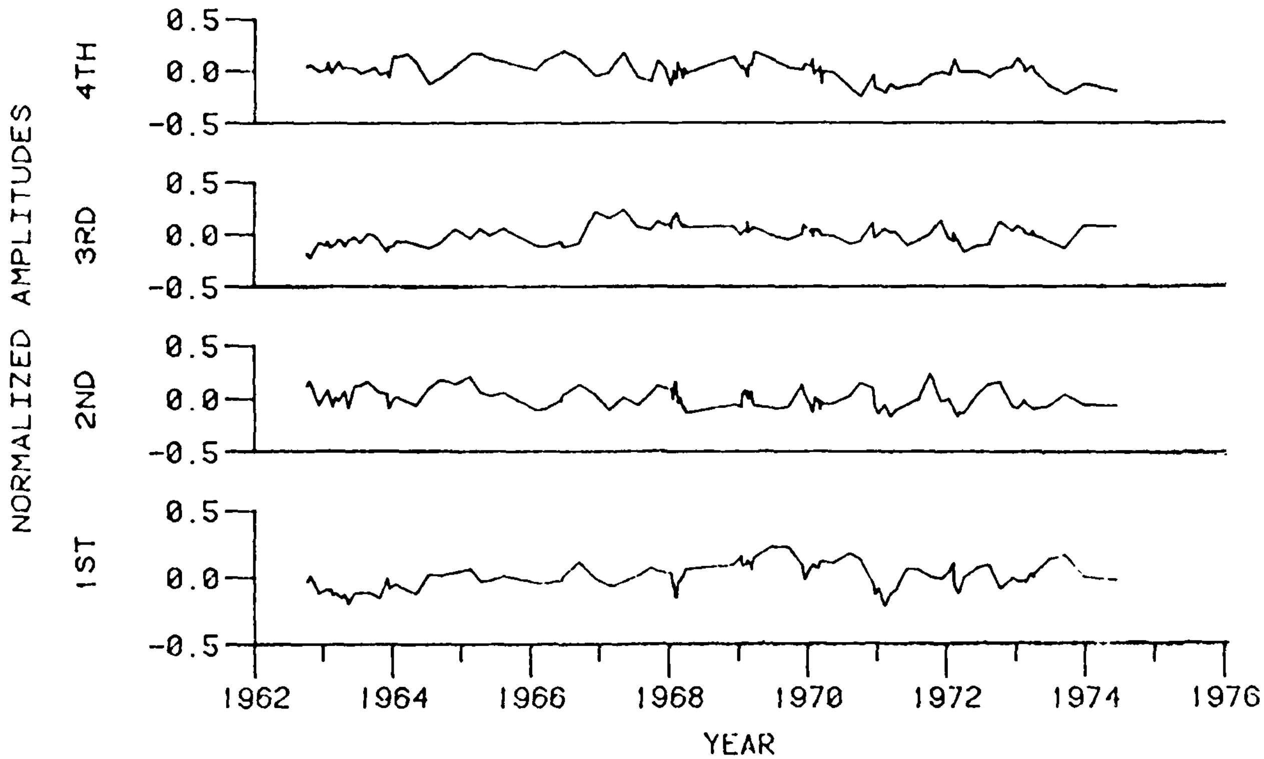

Figure 41. Temporal eigenfunctions demeaned, profile line 12

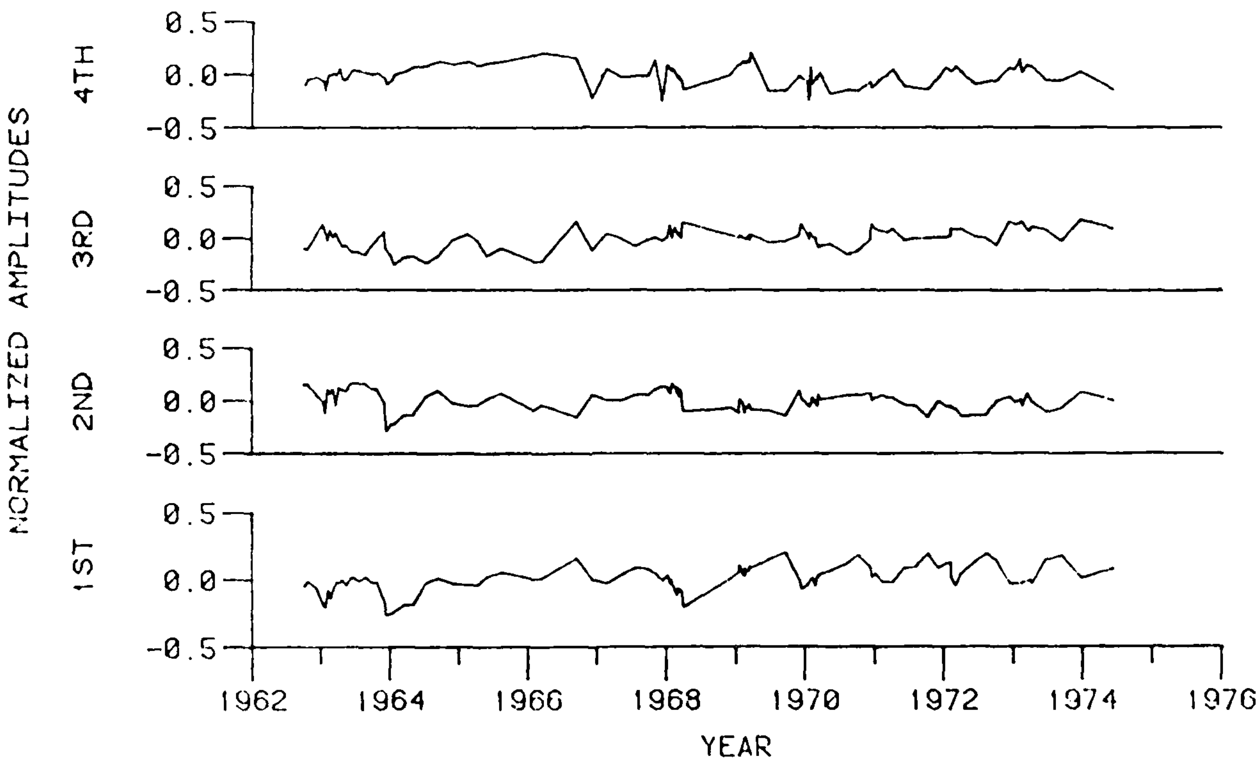

Figure 42. Temporal eigenfunctions demeaned, profile line 13

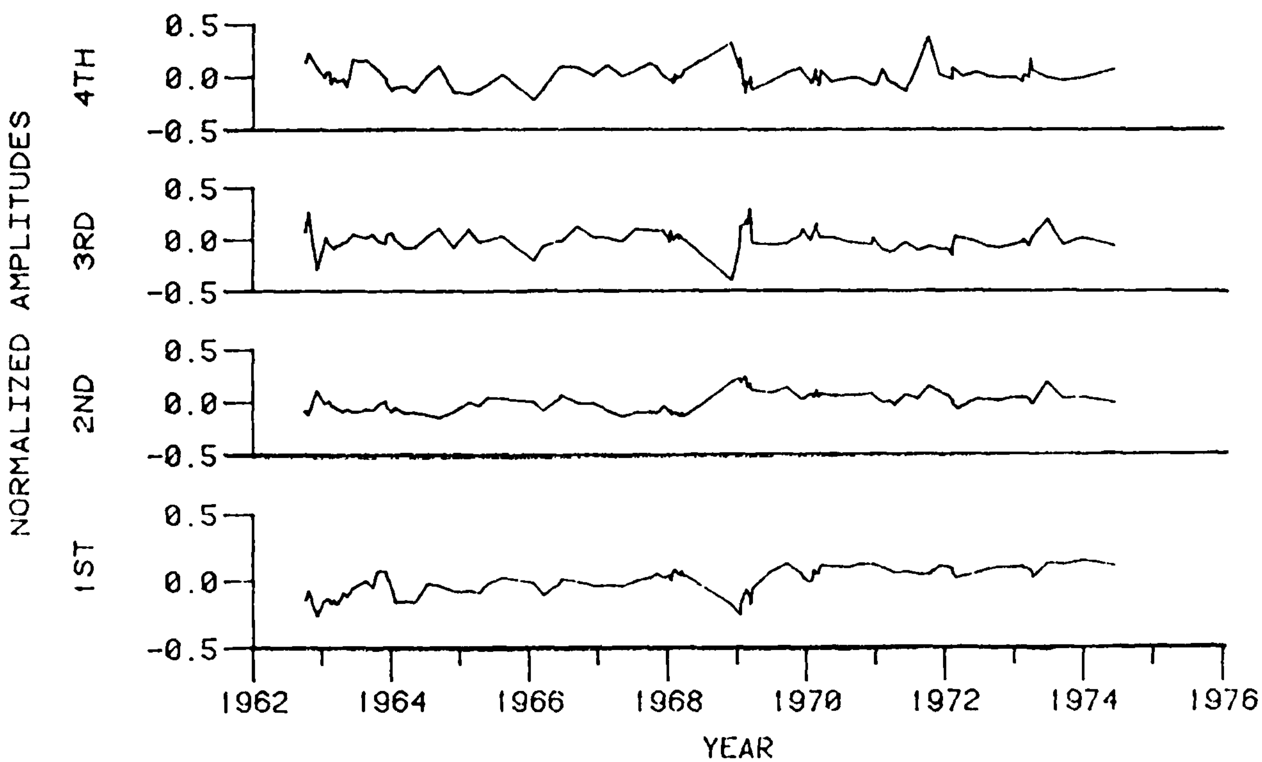

Figure 43. Temporal eigenfunctions demeaned, profile line 14

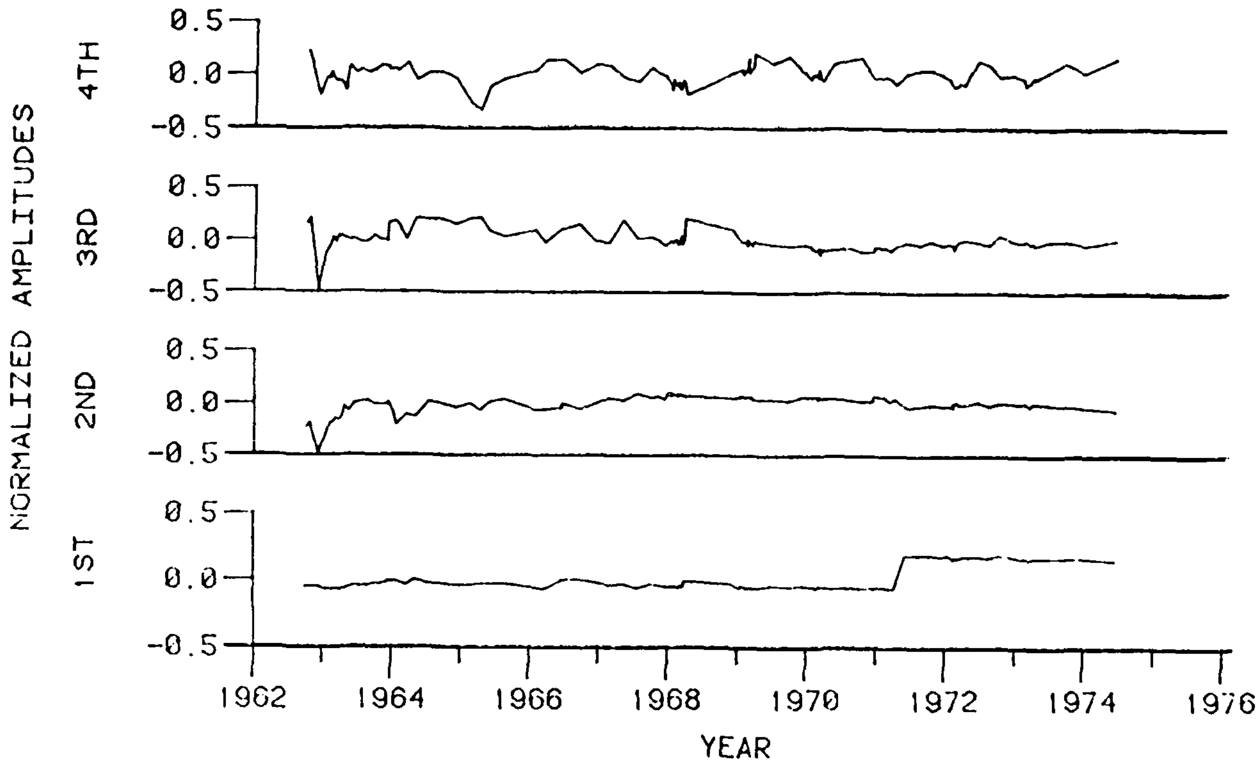

Figure 44. Temporal eigenfunctions demeaned, profile line 15

1969, when there was a sizeable addition of sediment to the beach (Fig. 45). Profile line 17 shows a spatially variable change in sediment stored above MSL, with the greatest rate of change between 1962 and 1966 (Fig. 46). Profile line 18 shows two periods of beach erosion, the first from 1962 to 1971 and the second from 1971 to 1974 (Fig. 47). These two periods of erosion are separated by a sizeable increase in sediment volume between March 1971 and April 1971, resulting in a net gain of sediments over the study period.

Both of these analysis procedures show the overall long-term pattern for eastern Jones Beach from 1962 through 1974 to be gradual erosion, although distinct episodes of accretion (notably in 1969 and 1971) reduce the impact of this gradual erosion. Because these accretional events are so limited in time and represent such a large increase in sediment stored on the beach, they are most likely associated with man's beach management activities. The five westernmost lines (14-18) are undergoing significant accretion as a result of these nourishment episodes.

b. Seasonal Beach Changes. Seasonal patterns of beach change can be obscured by large, higher frequency storm changes when storms are evenly distributed throughout the year. Beach grooming and large longshore transport rates can also obscure or mask seasonal patterns of beach change. Because of the large inferred longshore sand transport rate along Jones Beach, seasonal changes can be expected to be small.

In fact, beach eigenfunctions reveal a small seasonal

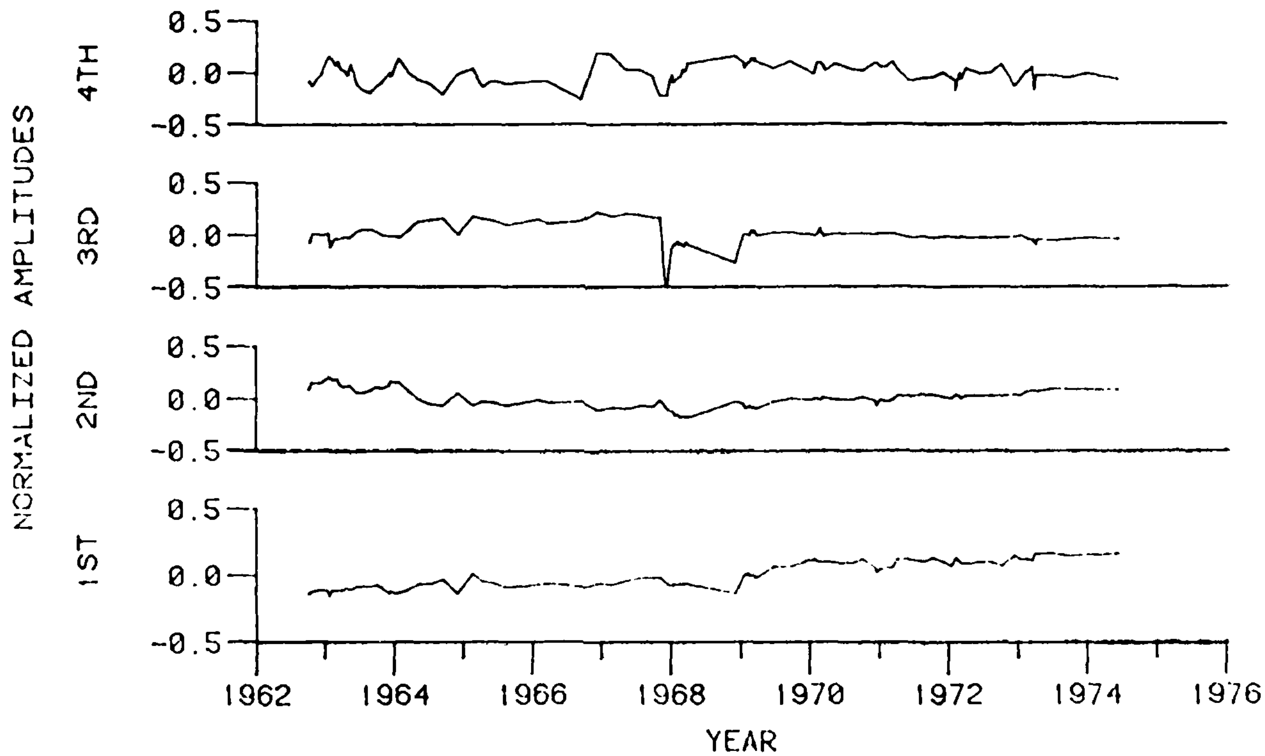

Figure 45. Temporal eigenfunctions demeaned, profile line 16

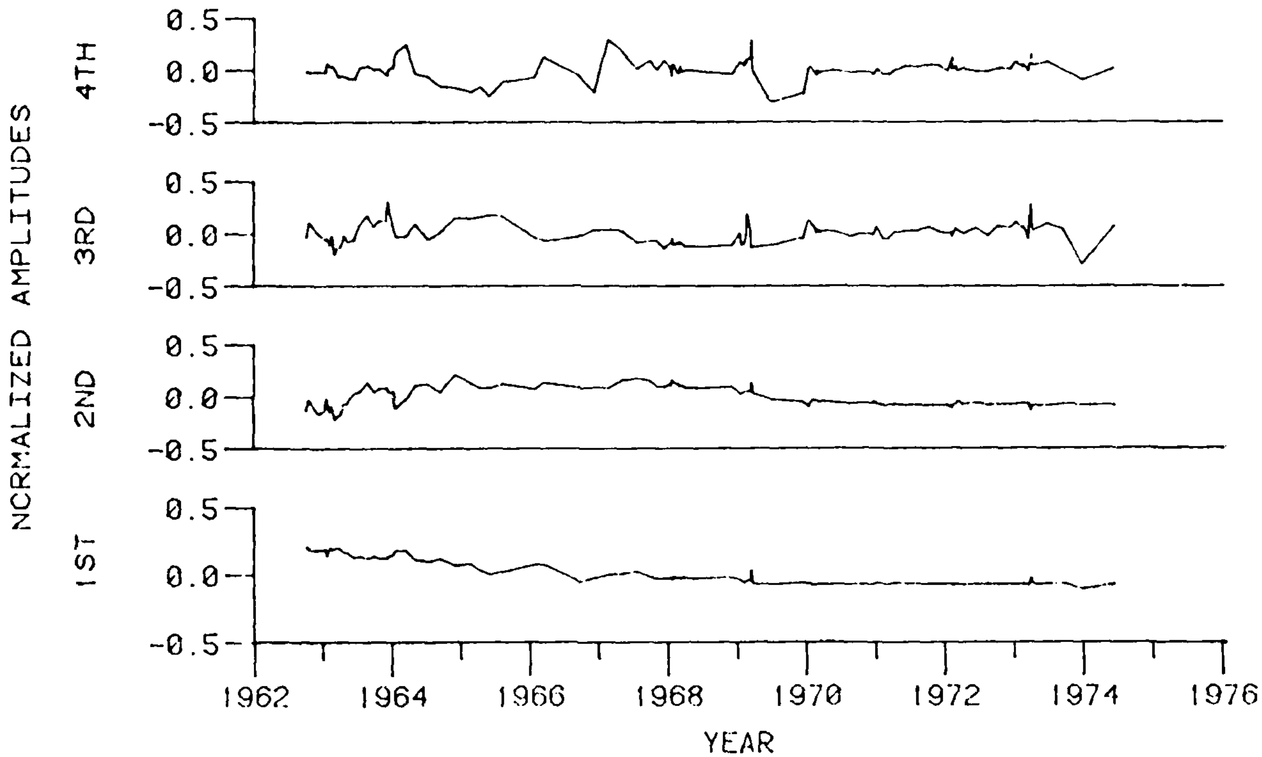

Figure 46. Temporal eigenfunctions demeaned, profile line 17

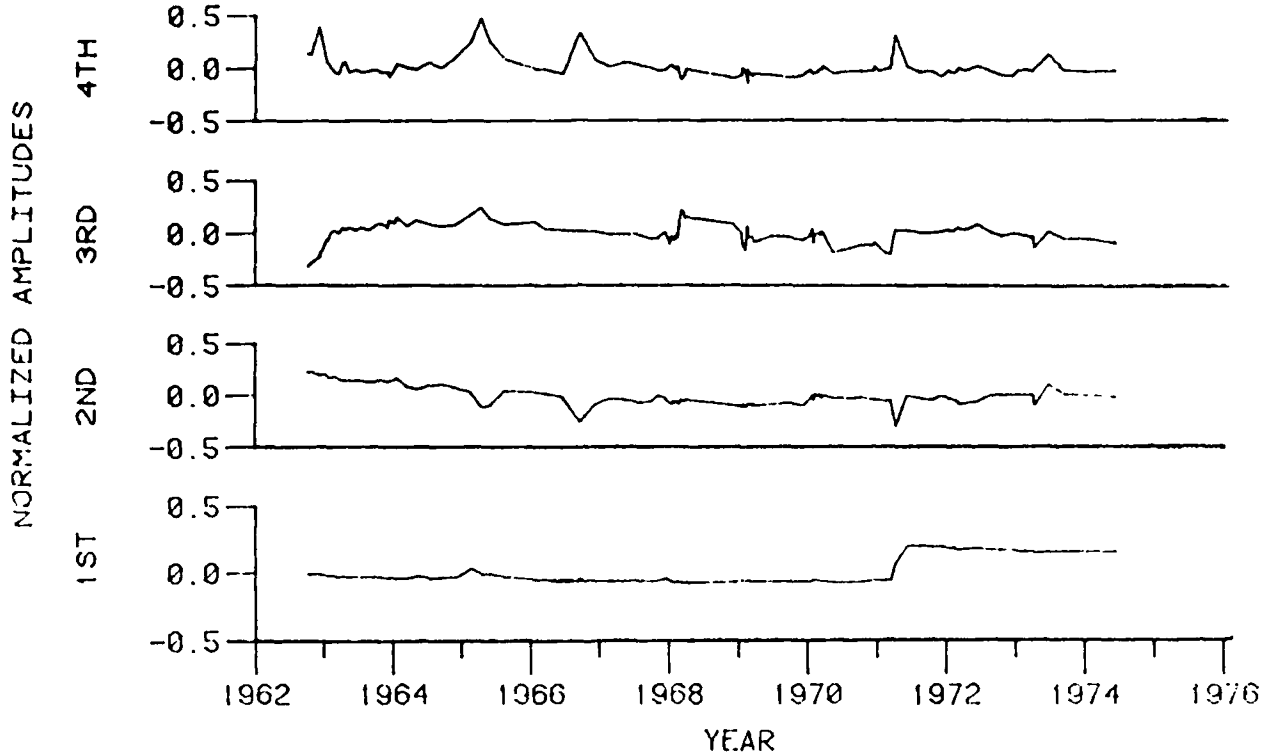

Figure 47. Temporal eigenfunctions demeaned, profile line 18

signature. There are no apparent seasonal changes at line 2 (Fig. 33), probably due to the large long-term erosional trend. Profile lines 3 and 4 (Figs. 34 and 35) show a seasonal tendency, marked by low sand volumes in the winter of some years. Profile line 8 shows perhaps the largest seasonal signature (Fig. 37), with the remainder of the profiles showing variable seasonality (large some years, low in others). Trends at profile lines 15, 16, and 18 are obscured by larger changes which alter the sand volume in a profile over the time period of a month or so (see previous section on long-term changes).

An indication of the magnitude of seasonal beach change is the mean square value of the beach profile data over the period of the study (Table 3). Omitting line 2, which has an overwhelming long-term erosional trend, the remainder of the profile changes have an average mean square value of 0.249 square meters, with profile lines 3, 4, 7, 11, 15, and 18 grouped closely (with an average of 0.367 square meter) and lines 8, 9, 10, 12, 13, 14, 16, and 17 grouped closely (with an average of 0.160 square meter). The lesser of these two mean square values (0.160 square meter) probably represents a better estimate of the seasonal response of the Jones Beach profile lines. These seasonal responses can be compared to those at Fairfield/Milford, Connecticut, beaches (0.031 square meter, Morton et al., 1983); Misquamicut, Rhode Island, beaches (0.069 square meter, Morton et al., 1984); Cape Cod, Massachusetts, beaches (0.5 square meter, Miller and Aubrey, 1984); or Southern California beaches (0.2 square meter, Aubrey, 1979). The open ocean beaches (Cape Cod, Southern California, and Long Island) all have larger beach variances than do more protected beaches

(Fairfield/Milford and Misquamicut). This is partly a reflection of exposure to open ocean waves, surf zone structures, offshore bathymetry, and available sediment.

Above mean sea level volume plots (Figs. 18-32) show a clear seasonal trend superimposed on longer scale trends. The seasonal behavior is clearer on MSL-volume plots than from eigenfunction plots.

c. Short Term Beach Changes. Profile data for the period October 1962 to June 1974 indicate that the shoreline in the area between Jones Inlet and Fire Island Inlet can display significant short-term variability. The majority of these variations appears to be the result of naturally occurring erosion-accretion cycles induced by the passage of high energy storm events. As discussed in previous reports in this series, two primary storm types impact the New York-New England area: the tropical storm, generally an intense low pressure system formed over the southern North Atlantic and propagating to the north and east along the east coast of the United States, and the more common coastal storm produced by the passage of a low pressure system initially formed inland (in the midwest or central Canada) or along the east coast (typically in the vicinity of Cape Hatteras). The impact of these events on the beach depends primarily on the intensity of the individual storm, its trajectory, and the antecedent beach configuration. For storms of equal intensity, maximum energy conditions along the beach result from storms tracking to the east of the site. A number of significant storm events occurred during the BEP survey period, and the resultant profile data provide some insight into

associated short-term beach response.

Storm of 14-15 January 1968. This coastal storm was the result of a low pressure system which formed in the southeastern coastal states in the wake of an intense high pressure system that had dominated the weather of the east coast since January 9th. The low formed initially on the 12th and slowly moved northeastward toward the coast. On the 14th, the storm center was positioned just west of Roanoke, Virginia, and its influence extended northward to the vicinity of New York City. Winds that had been predominantly northerly in direction during the high (Fig. 48) began to progressively shift to the northeast, east, southeast, and finally southwest as the low progressed northward. The storm center passed over the New York area on the night of the 14th and proceeded along a northeasterly track into the Canadian maritimes. Maximum winds during this storm appear to have been southwesterly.

Beachfront profiles obtained on January 15th indicate that the passage of this storm produced significant erosion along most of the area between Jones and Fire Island Inlets. Only in the vicinity of line 3 was slight accretion observed. The remaining profiles indicated erosion with maximum loss occurring in the vicinity of profile line 16 where approximately 23 cubic meters per meter was displaced. Similarly high losses were observed at lines 2, 10, and 18. The data indicate generalized erosion with little evidence of a favored spatial trend in which erosion is confined to the eastern or western end of the beach. On average the beachfront lost approximately 13 cubic meters per meter due to this storm. Poststorm surveys indicate that beach

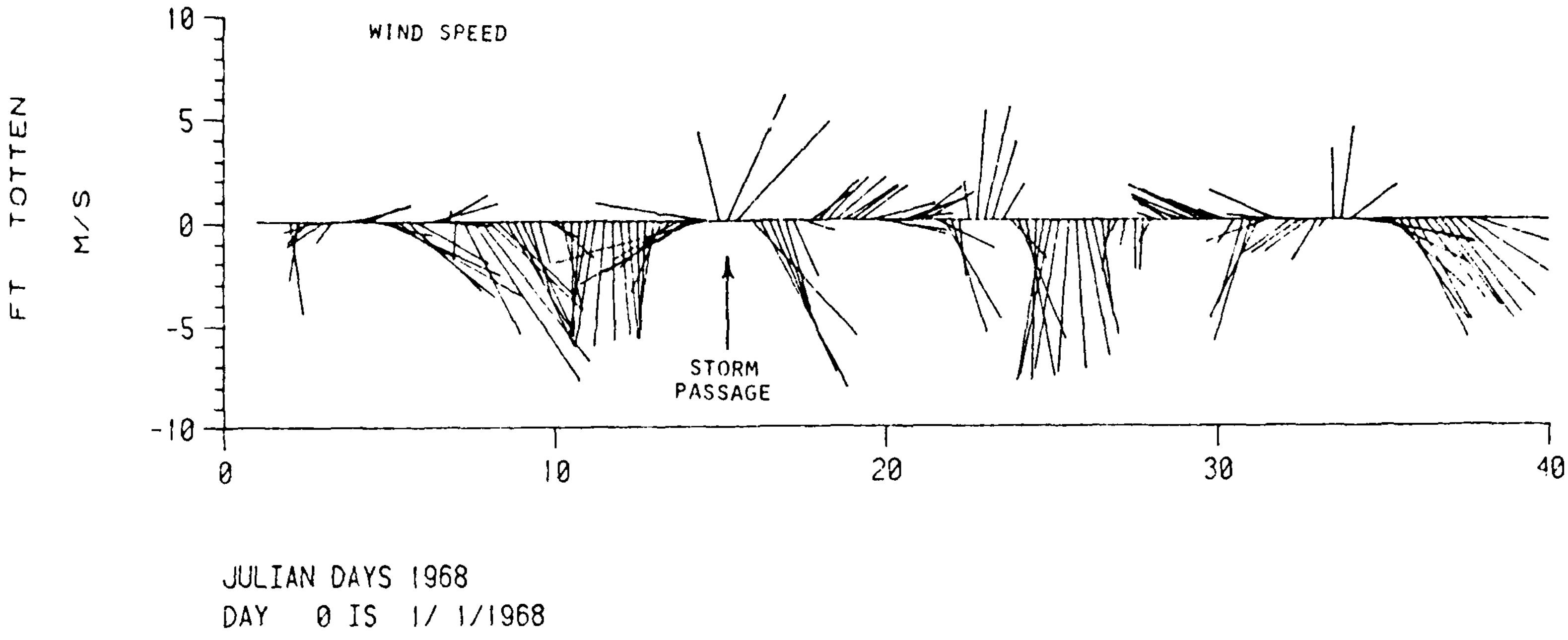

Figure 48. Storm of 14-15 January 1968, wind data

recovery of the area was extremely rapid, with the bulk of this beach loss recovered by January 22nd. Similar rapid recovery has been reported for other beaches along the south shore of Long Island (DeWall, 1979).

Storm of 11 December 1969. This storm was produced by the passage of a low pressure system formed initially over northwestern Florida along the southern limit of a large cold front extending north along the entire eastern seaboard. This low which followed a northerly track, passed to the west of New York City on December 11th and proceeded into Canada. Winds for the period preceding the storm were primarily from the northwest (Fig. 49). As the storm approached, winds shifted clockwise from the northwest through the northeast to the southeast and then the southwest. Winds from the southerly direction displayed maximum sustained speeds. In addition to the wind shifts, storm passage also produced a significant tidal anomaly. Observations at the Battery (Fig. 49) indicate an increase in maximum tidal stand of approximately 20 centimeters.

Profile data indicate that the storm of December 11th produced significant erosion along the project beach. All profiles showed losses with the exception of profile line 4 which experienced a negligible gain. Maximum losses occurred in the vicinity of line 3 where approximately 40 cubic meters per meter were displaced. Although trends are difficult to detect, there is a suggestion of increased erosion along the eastern end of the beach, with the bulk of the losses occurring from line 9 eastward. On the average, the beachfront lost approximately 13 cubic meters per meter due to this storm. Following surveys indicate that this

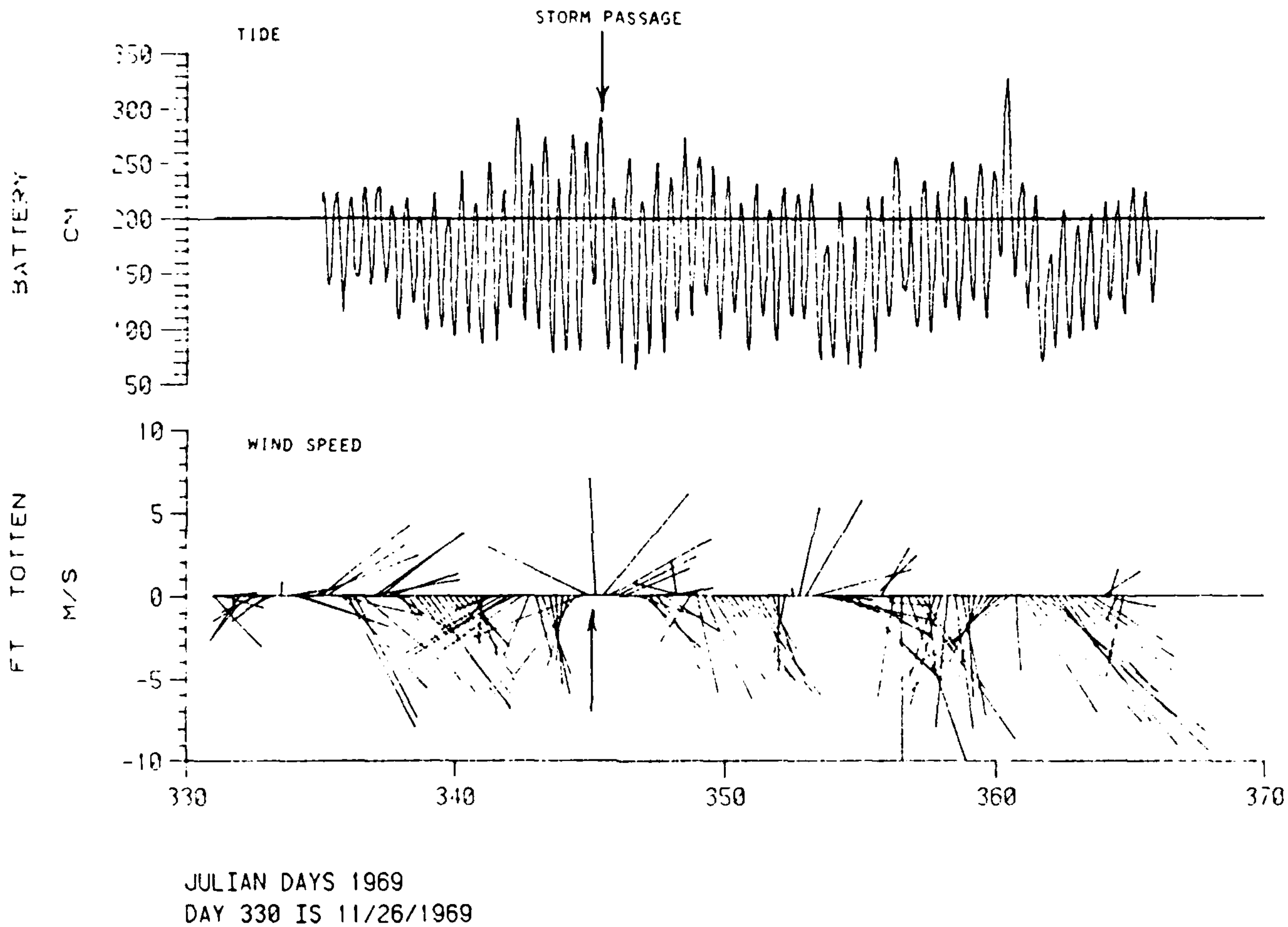

Figure 49. Storm of 11 December 1969, wind and tide data

volume of material was regained within approximately one month.

Storm of 26 January 1970. The response of the beachfront to the storm of 26 January 1970, provides some useful indication of the effect of a relatively low intensity storm. This storm formed initially over Illinois on the 24th and 25th. It moved steadily eastward over the next two days and decreased slightly in intensity. On the 26th it passed over the study area, proceeded seaward, and dissipated. The winds preceding storm passage were primarily northwesterlies (Fig. 50). As the storm center passed over the area the winds shifted into the southerly quadrant. Average wind speed seldom exceeded 5 meters per second. There was no apparent tidal anomaly associated with this system.

Despite the limited intensity of this event, profile data indicate that it was sufficient to cause moderate erosion along the study beach. Maximum erosion occurred in the vicinity of Line 18, where approximately 52 cubic meters per meter were displaced. The storm appeared to cause erosion along the western end of the beach, with the bulk of the losses being observed between lines 14 and 18. Further east, erosion alternated with accretion. Overall, the pattern was slightly more variable than observed during more intense storm events. The event produced an average loss of materials of approximately 10 cubic meters per meter. This amount was regained in approximately two months despite the occurrence of another low intensity storm during February.

Storm of 17 December 1970. The effects of this relatively high intensity storm on the beachfront between Jones and Fire Island Inlets have been reported in detail by DeWall et

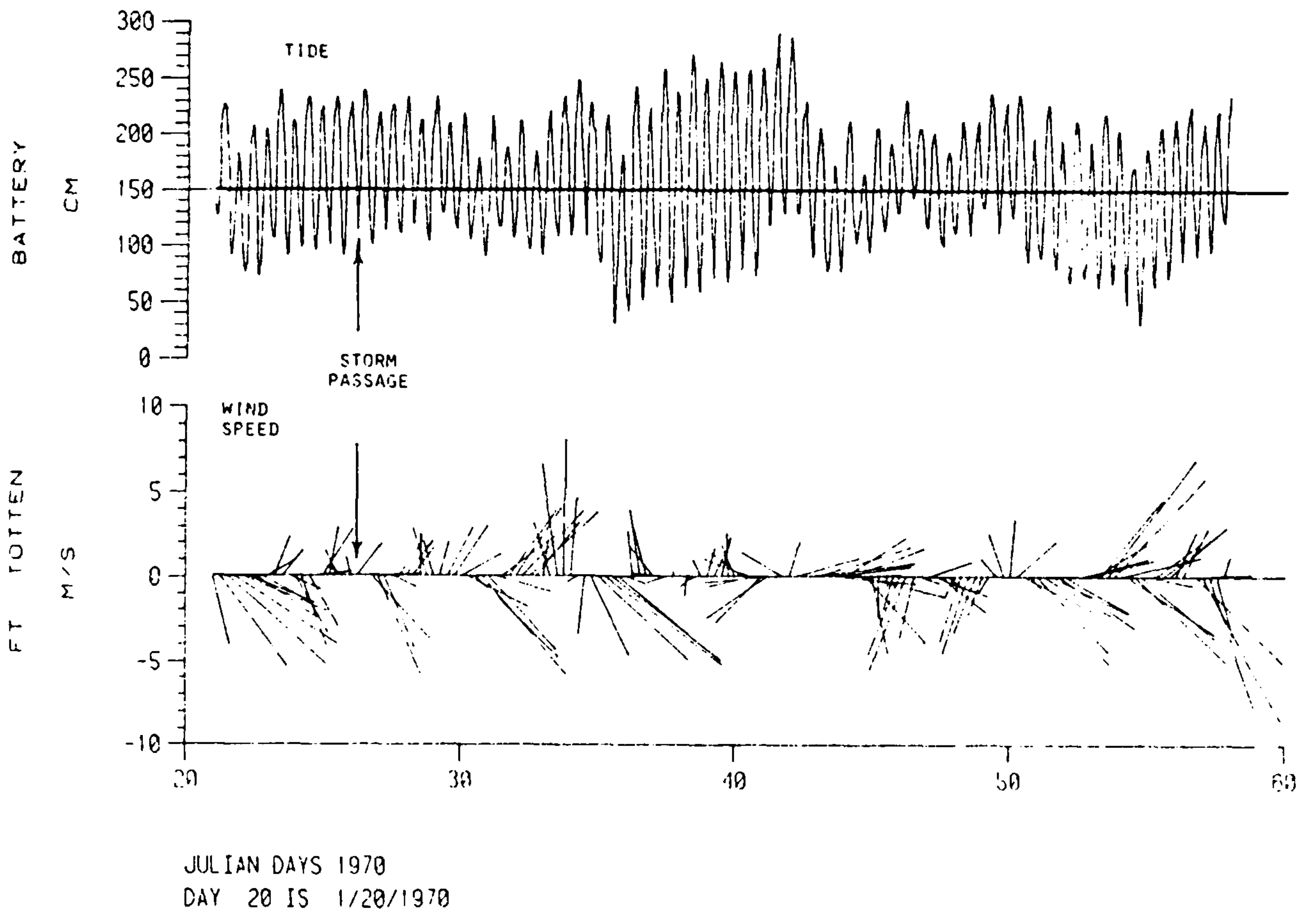

Figure 50. Storm of 26 January 1970, wind and tide data

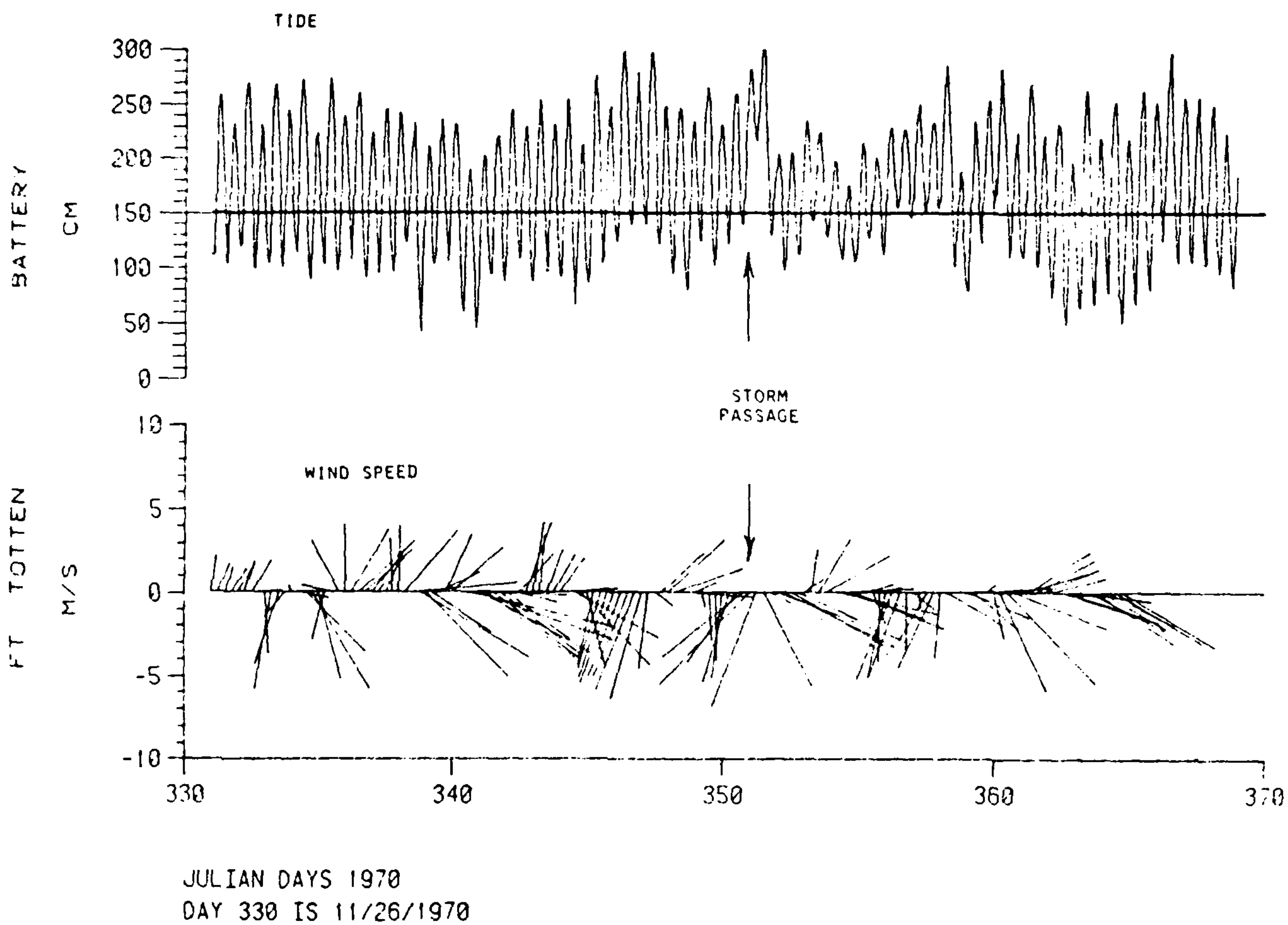

Figure 51. Storm of 17 December 1970, wind and tide data

al. (1977). Very briefly, this storm (Fig. 51), rich in southerly wind components, served to generate a high energy wave field with maximum heights of approximately 3.4 meters and periods of 12 seconds. The system also generated a significant surge having an amplitude of approximately 1 meter at Sandy Hook. This combination of factors served to produce major erosion along the study beach. These losses were distributed along the length of the beach. On the average, the beachfront lost approximately 18 cubic meters per meter during this storm. Surveys indicate that approximately 4 months passed before tranport had restored these losses.

Storms of 26 January through 9 February 1971. During this period, three relatively intense storms passed over the New York area. The first system was dominated by a large low-pressure cell initially formed in the Midwest on the 25th. It migrated northeastward and passed west of the study area on the 27th. Passage caused a shift in the prevailing winds from the northwest back to the southwest to the northeast and finally into the northwest again as a high-pressure cell moved in behind the system. In addition to the wind shifts, the passage of the low produced a significant tidal anomaly characterized by both a setup of approximately 20 centimeters (Fig. 52). The second storm moved over the area on the 30th of January. Again this was a system that had formed in the Midwest and its track was quite similar to the 26th storm. The resultant wind shifts were also similar although less evident. No significant tidal anomaly was associated with this system. The third storm affecting the area formed over Cape Hatteras and moved rapidly past the study area on the 9th of February. The system favored the characteristic wind

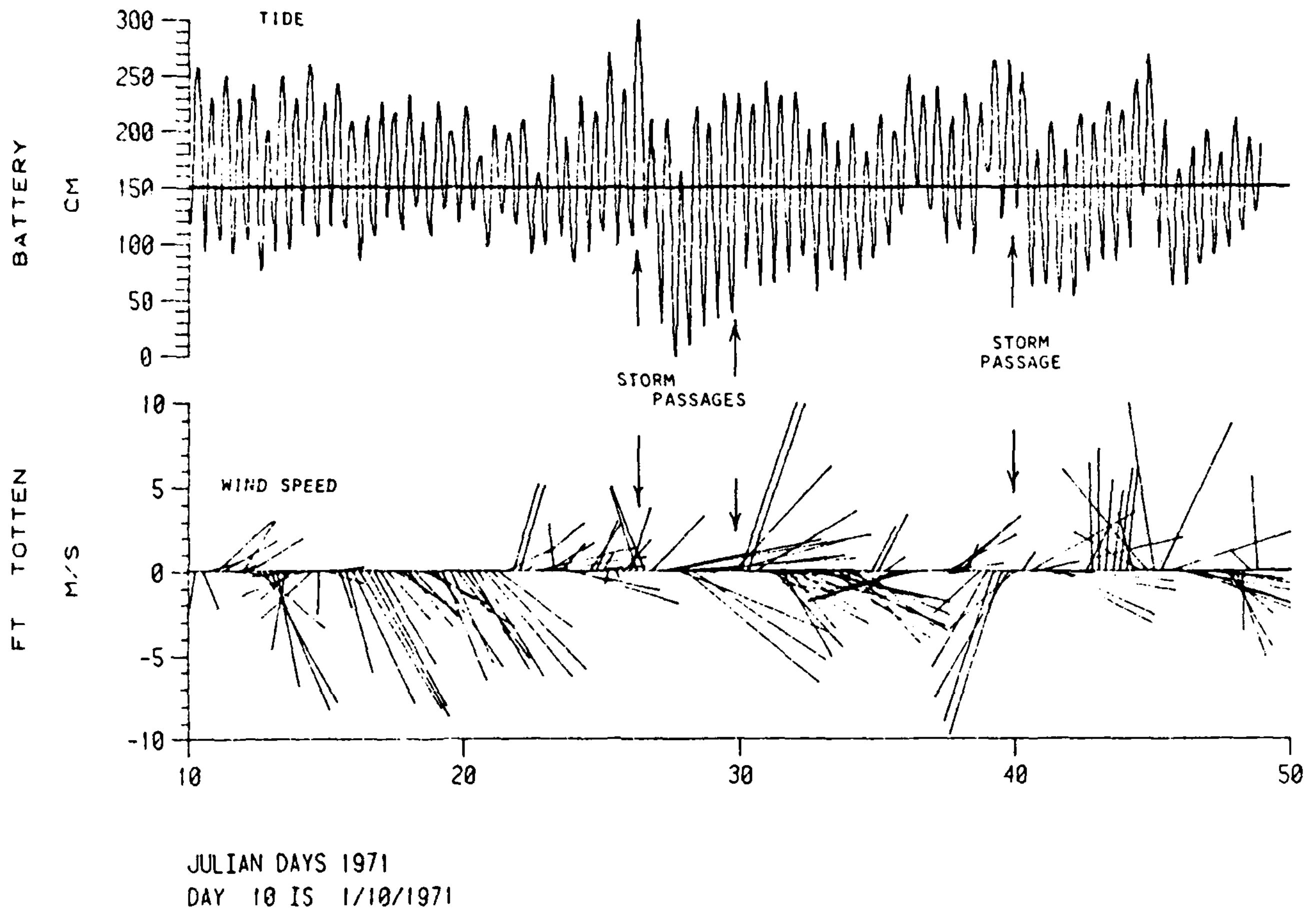

Figure 52. Storms of 26 January through 9 February 1971, wind and tide data

shift and served to produce a significant tidal anomaly (Fig. 52).

In combination, the three storms of late January and early February 1971 served to produce major erosion along most of the shorefront between Jones Inlet and Fire Island Inlet. Maximum erosion occurred in the vicinity of line 15 where approximately 56 cubic meters per meter were displaced. The majority of the profile lines displayed losses in excess of 15 cubic meters per meter. The magnitude of these losses in comparison to those observed during preceding storm events suggests that the effects of the three storms were cumulative. There is no indication that an equilibrium condition had been achieved in which further storm impacts would be reduced. Overall the beachfront lost an average of 20 cubic meters per meter due to these storm events. These losses were regained by April.

3. <u>Longshore Sand Transport</u>

Previous reports of longshore sand transport rates along Jones Beach vary from 400,000 to 600,000 cubic meters per year Panuzio, 1969; McCormick and Toscano, 1980). All estimates are based on measurements of accretion against inlet jetties (Fire Island and Jones Inlets). Data gathered in conjunction with the BEP study of Jones Beach reported here do not provide more information to improve the estimate of longshore transport rate or the relative magnitudes of easterly versus westerly transport.

The only source of directional wave data available for this area is the BEP observation program from 1968 to 1974. Quantitative use of these data for longshore transport estimates is not justified for several reasons. First, the direction

windows are too broad to allow adequate estimates. Second, the wave observation program was biased toward winter observations and almost no observations were made during the summer season. Third, the spectral ocean is approximated in the collected data by a single period and single height; this approximation will degrade estimates of longshore sand transport that make use of the data.

As a result, the best estimates of longshore sand transport for the area are based on accretion of material against structures and dispersal of dredge spoil. As previously mentioned, there are periods when longshore transport is to the east, as documented by dispersal patterns of dredge spoil material. These indirect indicators of longshore sand transport show that structures have a major effect on beach stability at Jones Beach. Since Fire Island Inlet traps most sediment moving to the west, and shelters the eastern-most sections of Jones Beach from waves with potential for westerly transport (thereby trapping sediment and removing it from the more westward beach sections), the central and western portions of the beach are deprived of sand sources. This can only be remedied by introducing more sand, either through disposal of dredge spoils or onshore sand transport. The structures, therefore, have irretrievably altered the natural transport patterns along Jones Beach and exert a major erosional effect on central Jones Beach. The Jones Beach inlet jetties cause accretion on western Jones Beach, as sand eroding from central and eastern Jones Beach is trapped there.

V. SUMMARY

Jones Beach is a 24-kilometer section of the extensive barrier beaches of southern Long Island. Offshore bathymetry is generally regular on the large scale, with the exception of Hudson Canyon to the southwest. On a medium scale, the shelf offshore is replete with ridge and swale features. Closer to shore, the bedforms are dominated by longshore bars, often becoming shore attached.

Longshore sand transport in this area is intense, with an estimated annual net transport of 600,000 cubic meters. Most of this is trapped by Fire Island and Jones Inlet jetties, although some sand bypasses the jetties and is deposited in the navigation channels at the inlets. This longshore transport is in response to waves coming from slightly east of south, although wave statistics supporting this theory are poorly documented. This transport plays a dominant role in beach erosion along Jones Beach.

Over the long term, eastern Jones Beach has been gradually eroding because of lack of a sediment source to replace sand transported alongshore to the west. The previous source (Fire Island) was eliminated when jetties were built to stabilize Fire Island Inlet. To minimize this gradual starvation, Fire Island Inlet is periodically dredged, with spoil disposed on eastern Jones Beach. This sediment (4,000,000 cubic meters since 1958) has reduced the landward migration of Jones Beach. The western part of Jones Beach has accreted, as sand from the east is

trapped at Jones Inlet jetty.

Superimposed on the long-term erosional or accretional trend at Jones Beach is a persistent seasonal cycle. Winter storms consistently reduce beach levels from January through March (up to 56 cubic meters per meter of erosion). Rapid beach recovery is partly due to natural onshore transport and partly due to spring beach grooming activities. Both of these factors result in nearly complete beach recovery within one month following storm activity. Both beach eigenfunctions and above-MSL sand volume plots document this seasonal cycle.

Jones Beach is susceptible to wave damage from all offshore directions. Tropical storms, coastal storms, and inland storms can all erode the beaches in this vicinity. The rapid storm recovery discussed above seems to be typical of southern Long Island beaches (DeWall, 1979). In contrast, beaches along other similarly exposed coastlines often have a longer recovery time because of persistence of higher energy, higher frequency waves (Southern California, Aubrey, 1979).

Using the mean square value of beach profile data as an indicator of beach profile variability, Jones Beach is shown to be more typical of open ocean beaches (e.g., Cape Cod, Massachusetts; Southern California) than of more protected coastlines (southern Connecticut beaches, Rhode Island beaches). Compared to other open coast beaches described in this series of BEP reports, however, wave climate at Jones Beach is low, and the tidal range small (about 1 meter).

Man's activities have had a significant effect on beach behavior over the last 30 years. Construction of jetties at Fire

Island and Jones Inlets halted the westward progradation of these barriers and reduced availability of sediment to downdrift beaches. Only periodic beach renourishment associated with inlet dredging maintains the present shoreline position along Jones Beach. Beach-grooming activities further affect the natural beach cycles at Jones Beach, making beach configuration more uniform throughout the year.

In conclusion, Jones Beach appears to be fairly stable in the long term, if the present program of replenishment from Fire Island Inlet continues along with seasonal manual grooming and if storm events occur no more frequently than they have over the past few decades. The beach can be expected to retreat significantly faster if nourishment is halted.

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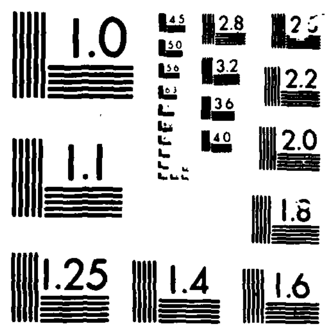

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